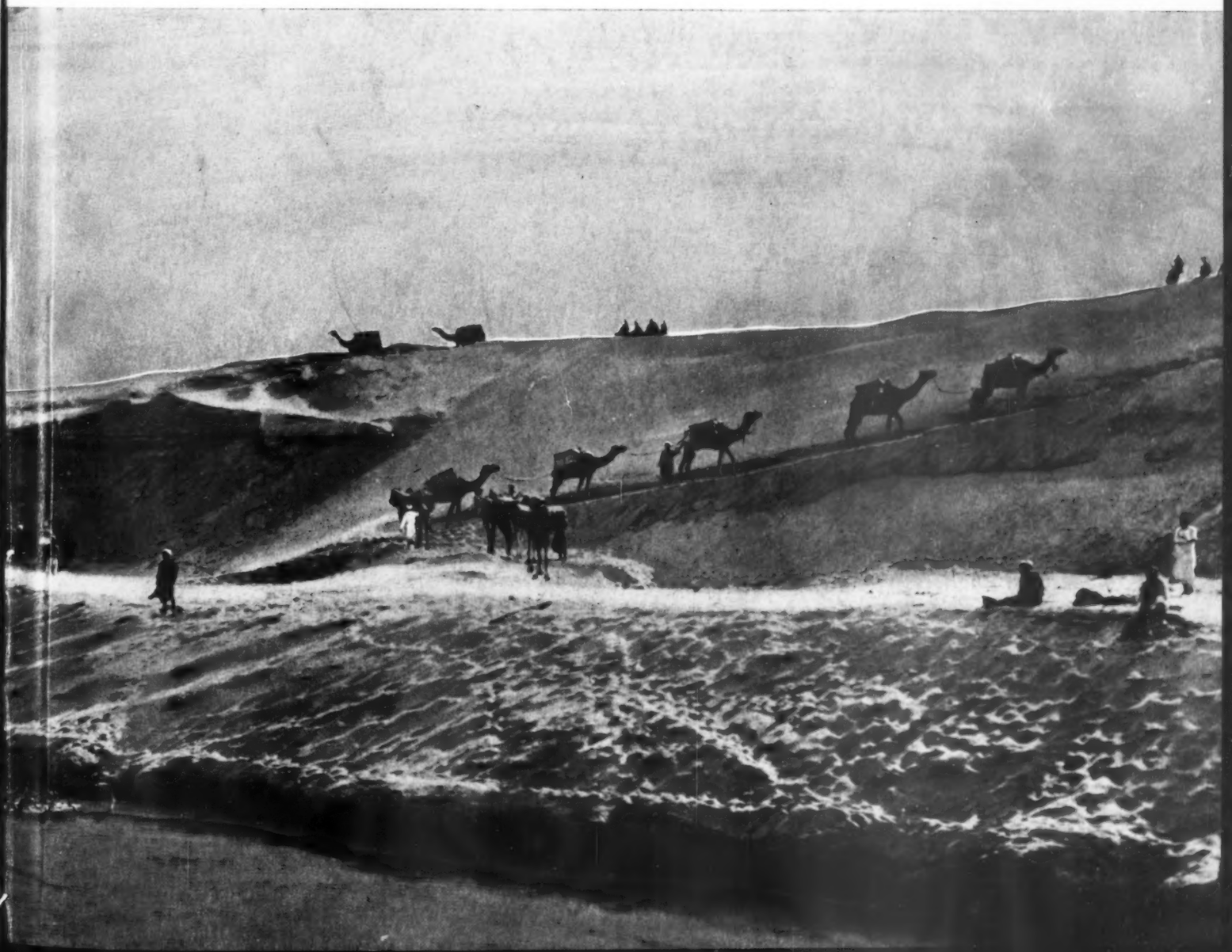
WORLD PETROLEUM

NEW YORK AND LONDON

JULY 1938

OIL ACTIVITY IN THE NEAR AND MIDDLE EAST



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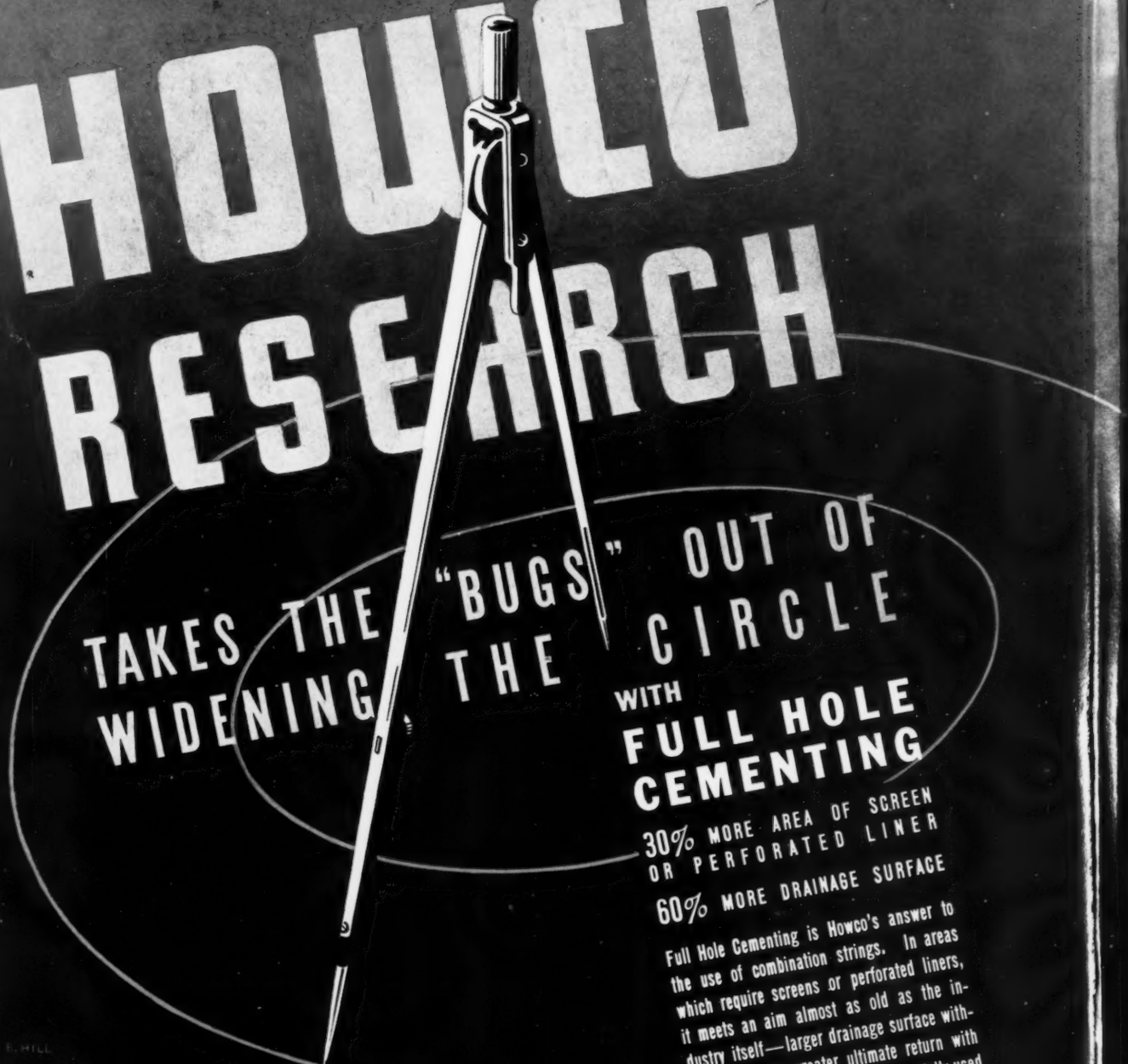

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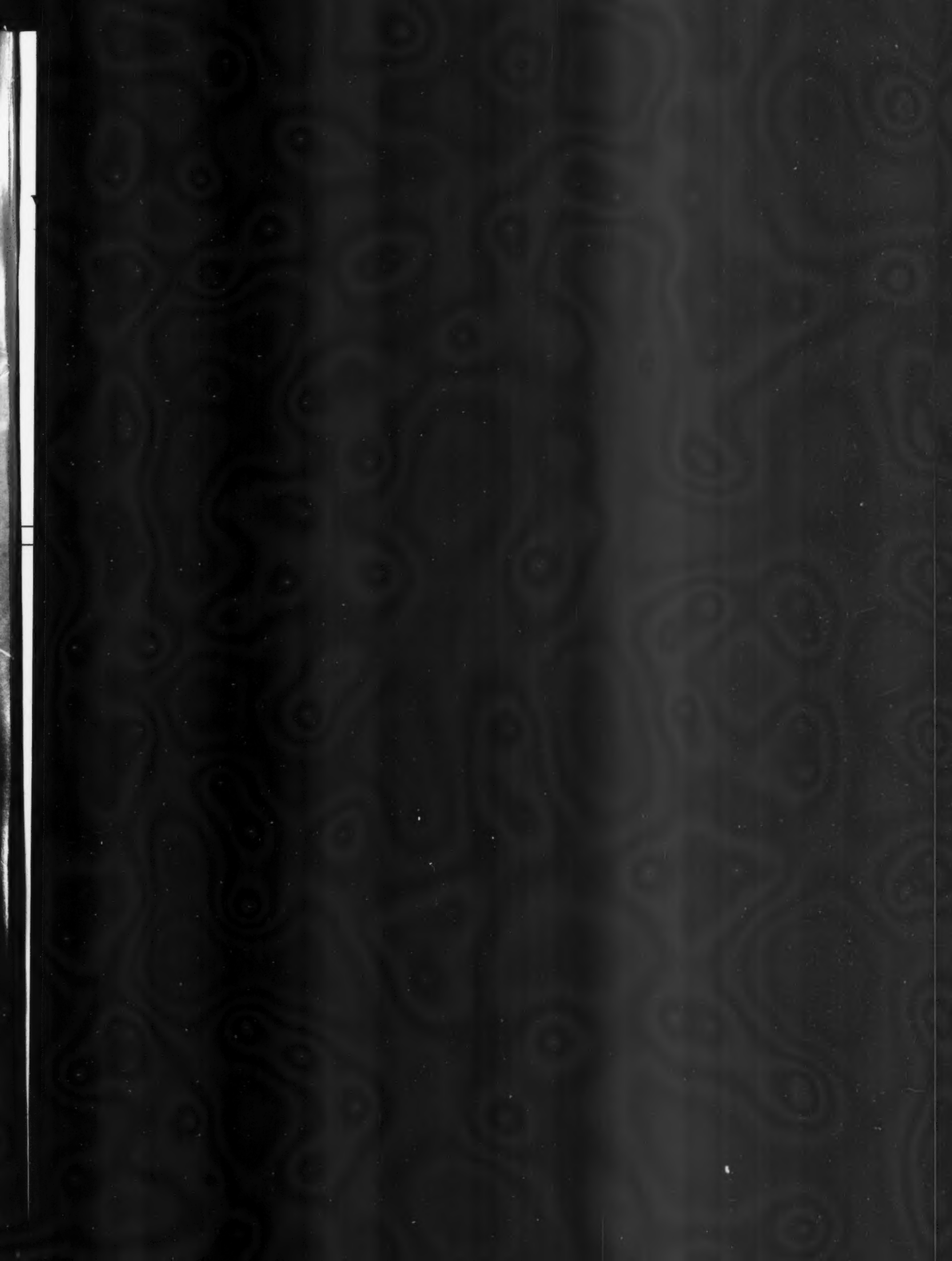

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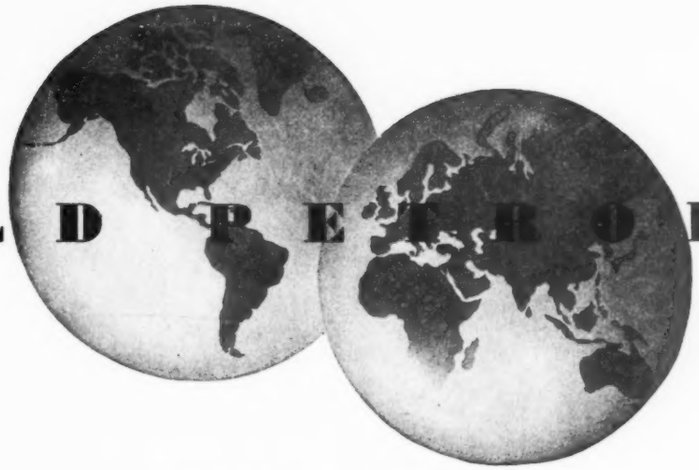

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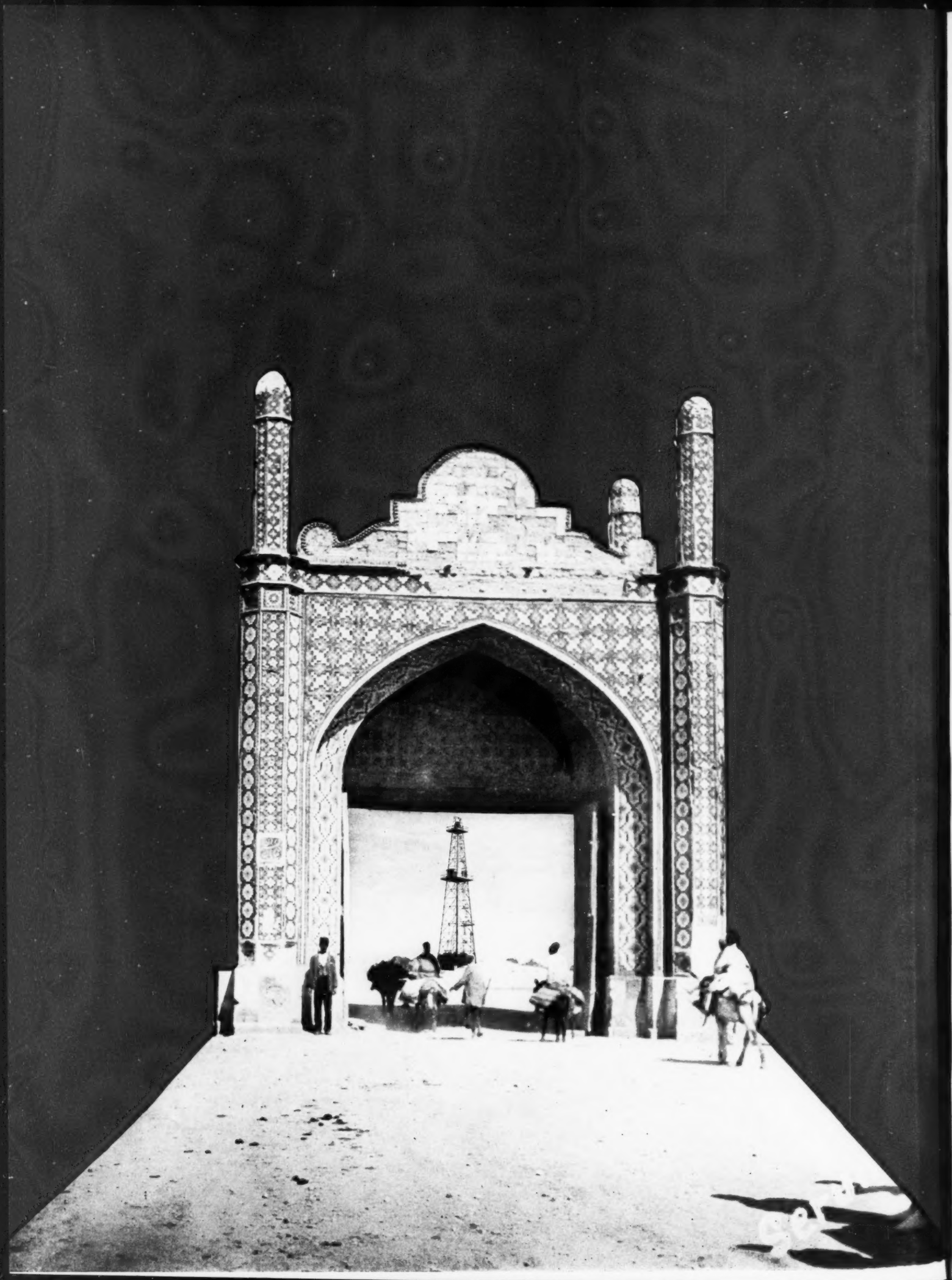
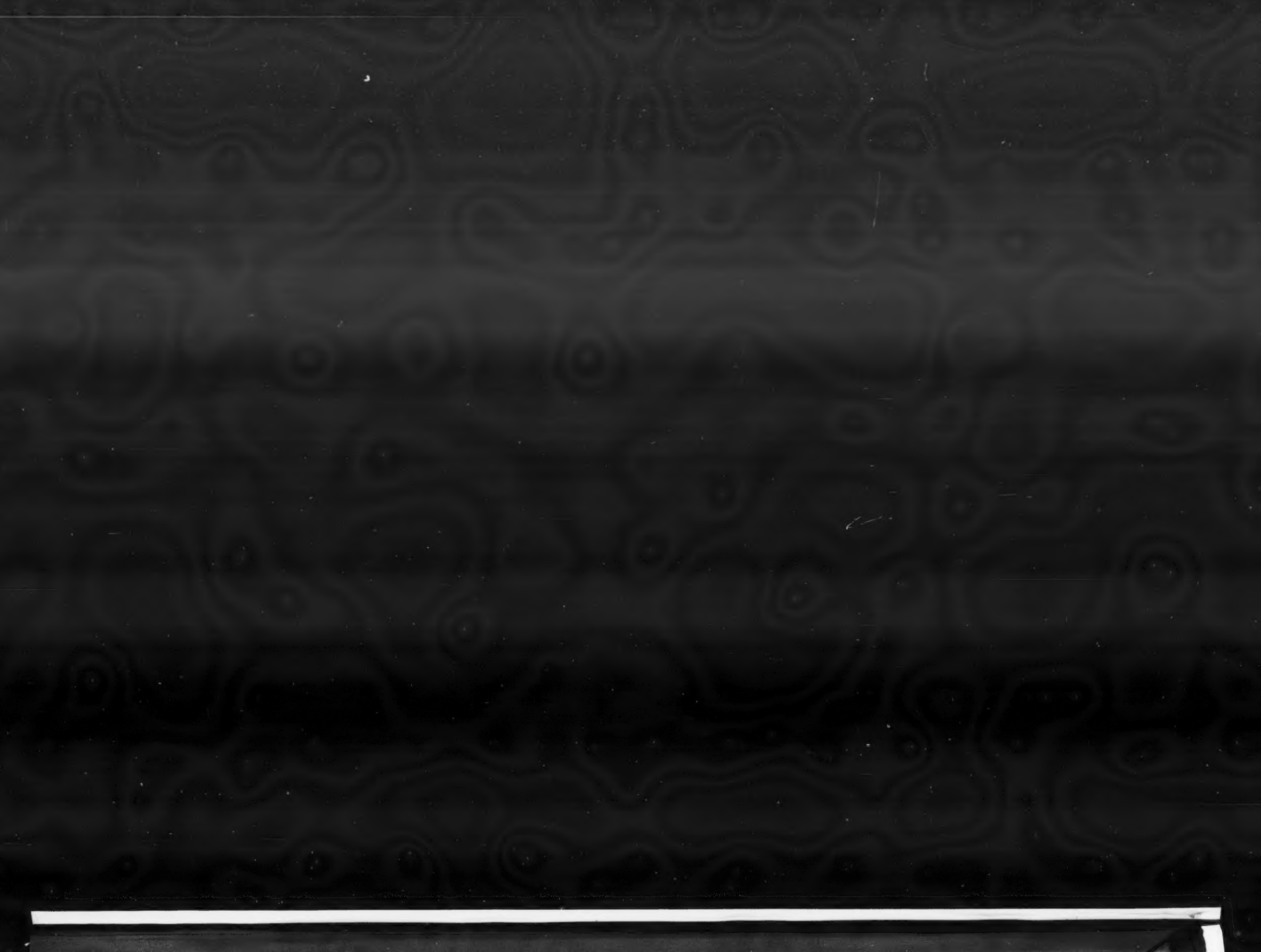




EDITORIAL

OIL IN THE NEAR AND MIDDLE EAST

IN no other part of the world is the search for oil being pursued more ardently or by a greater number of interests than in the Near and Middle East. This is partly of course because the discoveries already made mark this as one of the great actual and still greater potential sources of oil supply. Partly no doubt it is because the location of these fields gives them a special strategic importance. Lying within the area where the three continents of the Eastern Hemisphere meet, their product is within convenient shipping distance of all the main ports of Europe, Asia and Africa.

Aside from the world's ever growing hunger for oil, indeed, no special reason is needed to explain the eagerness with which exploration is being pushed throughout the Near and Middle East. While the usefulness of petroleum as an agent of power has long been recognized the fact that modern industry is becoming each year more and more completely dependent upon it adds steadily to its importance in this respect. In the council chambers of many a government a factor even more formidable is the absolutely essential part that petroleum plays in the conduct of present day warfare. At a time when the more powerful nations, while protesting their devotion to peace, are bending their every energy to feverish preparation for war, provision of petroleum supplies is a phase of preparation that cannot be neglected. All governments that aspire to play a part in future history have been studying of late, with care, and in many cases with considerable anxiety, the question of where they shall find their needed supplies of oil when war does come.

Very few countries are blessed with existing indigenous deposits sufficient for their needs. To all others the development of fresh fields is welcome because it lessens their risk of being left without imperatively needed products.

Since 1930 consumption of petroleum and its products has risen roundly 40 percent, but outside the United States the increase has been nearly 60 percent. As the most completely motorized of all countries the United States is far in the lead of all others in its use of oil but there is evidence that the rest of the world is starting out to catch up with America. Whether the outlook be for peace or for war any long time view is bound to raise the question as to where the vast quantities of oil certain to be required for future use are to come from. Part of the answer to this question is being supplied by the Near and Middle East. While Iran for some twenty years past has been supplying oil to parts of the East and to Europe it is only four years since the great pipeline across the deserts of Mesopotania placed the output of Kirkuk on the eastern shore of the Mediterranean. Since that time, however, activities in the vast territory from Egypt to India have moved at an accelerating pace. New fields have been discovered and are in process of development. Production has doubled and the entire area is being subjected to careful and exhaustive exploration. Some of this work already has yielded gratifying results; some of it remains for the future to evaluate. Enough has been done, however, to demonstrate that this area is destined to be one of the more important oil producing sections of the world.

Unlike the greater number of the world's oil fields those of the Near and Middle East have a rich historic background and a picturesque setting all their own. Here, where civilization itself was cradled, where mankind's first known history was made, where treasures of the past lie buried, man has come again for help in his struggle for the mastery of forces the very existence of which was undreamed of in those ancient days. It is a long, long swing of Time's pendulum that is bringing these eastern lands back to share in the progress that began here more than 5,000 years ago.

MEXICO'S Oil Industry After Expropriation

Government Engaged in Race Against Time to Find Export Markets—Shipments Far Below Normal—President Promises Better Conditions for Workers When Foreign Sales Increase—Criticism by the Press.

MEXICO CITY

MORE than three months have passed since the Mexican government confiscated the properties of foreign-owned oil companies and entered the oil business on a major scale for its own account. Yet conditions in the industry are far from normal and the economic situation has become steadily more acute. Settlement of the issue between the government and the oil companies appears more remote than it did on March 18 when President Lazaro Cardenas decreed expropriation. The companies adhere to the stand they have taken from the beginning that the only possible solution of the controversy is the return of the seized properties to their possession. This is practically the position of both the British and United States governments, for while the latter admits the rights of Mexico to expropriate it insists that such action can be made lawful only by "prompt, assured and effective payment," a condition that all parties admit is entirely beyond the power of Mexico to fulfil.

Still pending is the companies' appeal to the Supreme Court against the lower court's decision upholding the expropriation order. In view of the subservience of the Mexican judiciary to the executive power, it is not expected that the Supreme Court's decision, when rendered, will alter the situation. Executives of some of the oil companies are still here but they hold no communication with government officials. Diplomatic exchanges between Mexico City and Washington are continuing but apparently are making little progress toward ending the impasse.

Officially the Mexican government treats expropriation as an accomplished fact and regards the matter of recompense to the oil companies as a minor question to be determined by negotiation. Its strategy is to prolong these negotiations as much as possible. The only definite suggestion for indemnification was the offer by President Cardenas to pay the companies out of proceeds of export sales of oil. This is a settlement that the companies declare they will never accept because it would postpone the recovery of their investment for years or possibly forever and because they would be aiding in their own spoliation.

Many rumors are current, the latest being that the controversy would be settled within thirty days by return of the properties on an agreement by which they would retain 62 percent of the oil produced, less export taxes. This is scoffed at in official circles and very possibly has no more basis in fact than many other stories that spring up from day to day.

For the time being, at least, President Cardenas is far more concerned over the internal situation than with the protests of foreign governments or of the oil companies. To bolster the tottering finances of the nation, to quell rising disaffection in the ranks of labor and to silence criticism from other quarters he is staking everything on the possibility of finding markets for export oil. A number of sales have been made but these will absorb only a small part of the normal volume of exports. Delegations have been sent to various Latin American countries in an effort to drum up trade.

President Cardenas himself has been conducting a vigorous campaign to reassure the public and to hold the oil workers in line. In his recent tour of the oilfields he made many speeches charging that the oil companies exploited the riches of the country and conferred no benefits in return; that they hampered efforts at reform and stirred up discord so that it was necessary for the government to dispossess them. At the same time he has told the oil workers that it is their patriotic duty to make sacrifices in order to help the country through the present crisis which he admits is grave.

This line of talk has helped to sustain the enthusiasm with which the expropriation decree was received originally in spite of the fact that fewer men are employed and those at work are receiving less than before the oil companies were driven out. There have been many complaints among the workers and friction between the unions and government appointees has been almost continuous. The only open trouble at the present time is among the seafarers' section of the workers in the Coatzcoalcos fields in Vera Cruz because of the dismissal of their chief by union officials which they denounce as an act of favoritism. This row has hampered work in the Coatzcoalcos sector and on harbor improvements at Puerto Mexico but it appears to be a local disturbance.

The President has recognized the existence of this dissatisfaction among the workers and in an attempt to allay it has authorized the performance of economic and social works in oil producing districts. In the Poza Rica belt he has given instructions for the drilling of four oil wells, establishing a modern townsite for workers there, building a road to connect Poza Rica with the highway under construction between Mexico City and Tuxpan, a Vera Cruz oil port, reconstructing the pipeline from the Cacalilao oil fields to the Mata Redonda refinery, near Tampico, improving the road from the El Ebano oil belt that links with the Tampico-Panuco-Valles highway, building a pipeline from the Tuxpan terminal to connect with Penn Mex's oleoduct, repairing Penn Mex's pipeline from El Alamo, extending the road from Tampico to El Alamo to connect with the Mexico-Tuxpan highway and investing 500,000 pesos (some $115,000) to give Ciudad Madero, an oil town near Tampico, adequate potable water service.

The obstacle to carrying out these public works is that the federal treasury is without funds for their construction. Millions of pesos worth of other projects promised by the President to other parts of the country take precedence over these latest enterprises so that their accomplishment probably lies very far in the future.

In other quarters, too, protests against the position in which the nation finds itself are becoming vocal and they have even been voiced in speeches in the Senate.

Criticism of increasing sharpness is being directed against the government by the more independent newspapers because of the lack of definite information regarding actual conditions.

Excepting the announcement made shortly after expropriation that production was being held to 40 percent of normal, presumably meaning by normal an average of some 3,835,000 bbls. monthly which had obtained for more than a year prior to March 18, the government has kept mum about the output. Official estimates formerly

issued monthly covering the previous month's production and rectification of the output for the month before that have been discontinued. Responsible private sources in Mexico have ascertained that production in March and April was 700,000 and 900,000 bbls. respectively. The May output was about 1,500,000 bbls. Informed sources say that production increased with the advent of June and that it is averaging some 53,000 bbls. daily. But the government is silent about this matter.

According to the claim of the oil workers' union, domestic sales have increased by 15 percent since expropriation. In the absence of exact figures this statement cannot be checked but to outward appearances motor vehicles and oil-fueled transportation lines and machinery are running about at par. Complaint is heard about a drop in the quality of gasoline and it may be that more gallons are consumed because fewer miles can be run per gallon.

Petroleos Mexicanos, the official oil company, which soon after expropriation absorbed Petromex, the government's first oil business venture, which was merged with the General Administration of National Petroleum, declares that it is able to meet payrolls and all running expenses in full. Even though domestic business is up 15 percent as claimed, it must be extraordinarily profitable if it is able to support the whole industry, for in the past only the export trade was profitable.

Reports emanating from government sources are that a total quantity of 1,372,-621 bbl. has been shipped abroad since March 18. However, 3,784 bbl. of oil products have been imported from Texas according to the Mexican Consul at Laredo. One clear announcement was that a shipment of 7,950 bbl. of fuel oil and 2,900 bbl. of Diesel oil had gone to Montevideo for the account of the Uruguayan government. A number of shipments have been made of oil that belonged to independent operators who were not involved in the expropriation or in completion of contracts made before expropriation. Statements have gone out that only unquestioned government oil has been exported but this is belied by the fact that shipments have included products while the government's oil is in the form of crude.

Probably the most important transaction thus far concluded is one with W. R. Davis & Co. covering 10,000,000 bbl. of crude and products to be shipped over a period of eight months. It is reported that 90 percent of the shipments, including crude, gasoline and lubricants, will go to Germany. Payment is to be made 40 percent in cash and 60 percent in oil equipment and farm machinery made in Germany. A previous barter arrangement reported to have been made with Italy was said to provide for the shipment of Diesel and fuel oil in exchange for raw silk.

In a speech to oil workers of the Cerro Azul zone, Vera Cruz, President Cardenas admitted that exports had been relatively small. He promised all oil workers a marked improvement in their condition when exports began to move more freely. He acknowledged a shortage in transport equipment but asserted that the gov rnment had 18 tankers at its disposal.

The lack of definiteness in frequent official statements about export shipments has prompted some important newspapers to demand editorially that the administration be more specific about such news of first importance to Mexico in these times, to name buyers, countries to which shipments are made and the names of the tankers in which the consignments are dispatched. Petroleos Mexicanos issued a bulletin to the effect that $1,400,000 worth of oil and by-products were to be shipped to unnamed buyers and countries in 21 tankers from Tampico before the end of June. This bulletin prompted the important Mexico City newspaper, Excelsior, to chide the government editorially for its lack of clarity and to put into print reports that have circulated that the oil referred was contracted for before expropriation.

Indicative of the increasing financial stringency is the government's decision to withdraw the 100,000,000-peso issue of National Redemption bonds which was originally planned to provide funds toward payment for oil properties. This action is due presumably to failure of the public to subscribe. The explanation issued is that it was done "in order not to withdraw from circulation money that is needed in order to make possible a greater economic effort in all sectors of the country for the development of industry and agriculture."

The rift between the regular army and a considerable group in the Congress on the one hand and the C.T.M. (labor syndicate) backed by President Cardenas on the other seems to be steadily widening. On June 28 the Chamber of Deputies passed a new civil service law but eliminated a clause demanded by the C.T.M. and supported by the President giving federal employees the right to strike. The bill must still be acted upon by the Senate.

Resentment against labor leader Vicente Lombardo Toledano on the part of officers of the army, which dates back to the movement for formation of a workers militia, has been fanned into fresh flame by reported utterances of Lombardo Toledano in speeches made in the United States. It brought forth a statement signed by five colonels in which they say in part:

"Lombardo Toledano cannot hide now that he seeks the dissolution of the revolutionary army. One proof of this is the formation of the so-called workers' militia in order to install a proletarian dictatorship in Mexico.

"The army is tired of anti-army calumny by labor leaders like Lombardo who are seeking to fool the workers into starting a fight like that in Spain. The Mexican public may have the secure knowledge that the military officers will put an end to the calumny and insolence of perverse leaders who are exploiters of the working class."

While it might be easy to exaggerate the importance of utterances like this, the multiplication of such incidents shows a growing dissatisfaction with government policies and the tenseness of feeling created by recent events.

The position that has been taken by the Cardenas administration is that it can continue to operate the oil industry indefinitely with or without exports but that it cannot pay the indemnification promised to the companies unless obstructions against exports are removed. The latter part of this statement probably is true enough, but in the desperate financial plight of the government any funds received from sales of oil are almost certain to be applied to other urgent needs. The private companies were unable to make money from domestic sales at the prices they were permitted to charge and depended on the export trade for real profits. Export sales of oil and products in 1937 totaled 24,960,-335 bbl. as compared with 25,039,665 bbl. in 1936. In both years the United States and Great Britain were Mexico's best customers. These are the markets to which Mexico has been unable to sell since expropriation.

Even though the Cardenas administration succeeds in finding foreign purchasers for oil that will scarcely contribute to the settlement of its triangular dispute with the oil companies and with the governments of the United States and Great Britain. It may help in staving off the day of reckoning for mismanagement of the country's finances. If disapproval of the seizure is sufficiently strong in important consuming countries to keep the great volume of former exports from finding markets that day is assuredly near. With revenues from other sources declining and with the heavy financial drain imposed by the President's elaborate schemes of socialization the government is on the verge of bankruptcy and the operation of all its industries is becoming constantly more difficult.

Meanwhile, all the forces of propaganda are being brought into play to rally public support on the oil expropriation. Appeals by the printed word, speeches, radio and pictures are being spread by the government on a scale never before attempted.

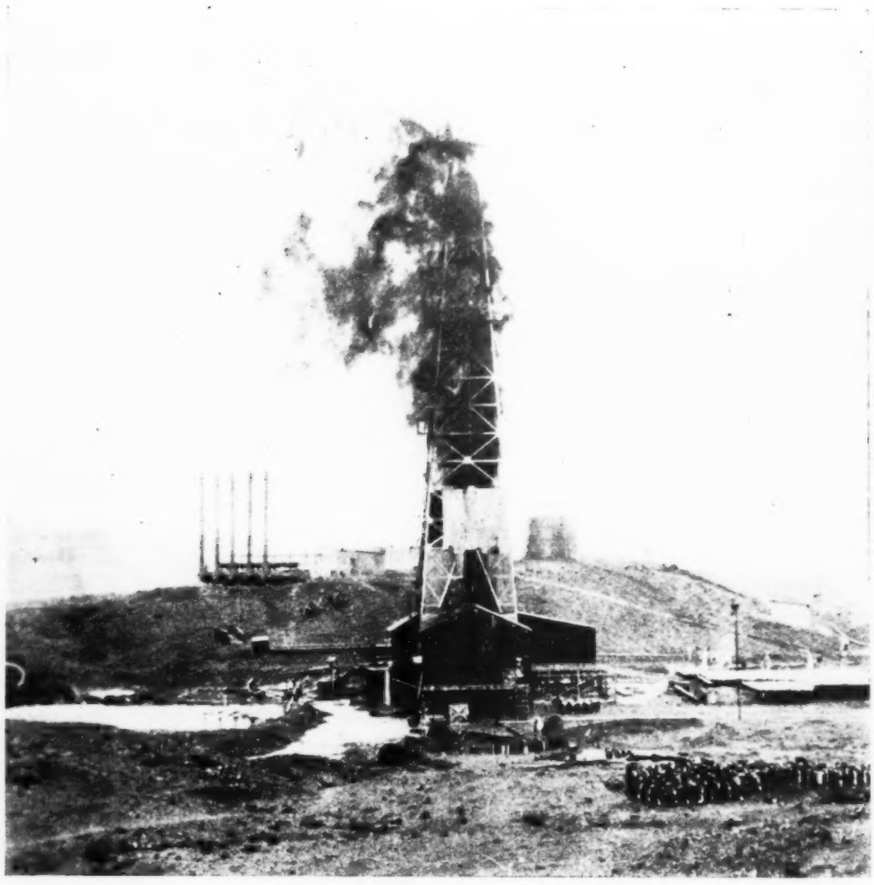
NEAR AND MIDDLE EAST A Theatre of Intensive Activity

Oil Interests of the World Participate in Search for Petroleum Deposits in Strategic Area East of Suez Where Vast Increase in Production Is Promised.

OLDEST and newest of the world's great oilfields lie within the Near and Middle East. Existence of petroleum deposits in that part of Western Asia between the Caspian Sea, the Mediterranean and the Indian Ocean has been known for hundreds, indeed for thousands, of years. It is probable that the first practical use of the pitch obtained from oil seepages and the first crude attempts at refining were made within this area. That the serious development of these resources should have been left to the Twentieth Century has been due to political and economic conditions.

Commercially, the rise of the Near and Middle East to a place of importance on the international oil map dates from the granting to William Knox D'Arcy by the government of Persia (now Iran) of a concession to explore for oil and from the development of that concession by the Anglo-Persian (now Anglo-Iranian) Oil Company Ltd. Beginning in 1912 Iran's contribution to the world's oil supply has risen to 77,000,000 bbl. in 1937, giving Iran fourth place among oil producing countries. It is not merely for the volume of their production that the oilfields of Iran are noteworthy, however. They are outstanding for the scientific skill with which they have been developed to insure long life and maximum recovery.

While the main production of oil in Iran has come from wells in the Masjid-i-Sulaiman and Haft Kel areas, north of Abadan, to which their output is conveyed by pipeline, a new field was brought in last year at Gach-i-Qaraghuli (since redesignated as the Gach Seran field) in southern Iran almost directly east of Abadan. The initial producer in this field flowed approximately 33,000 bbl. daily from a depth of 3,393 ft. at a pressure of 850 lbs. A well subsequently drilled produced at approximately 30,000 bbl. Further drilling is being done to delimit the structure which is expected to make an important addition to Iran's output. To utilize production from this district the company is considering the establishment of an export terminal and possibly a new refinery at a suitable point on the coast east of Abadan, probably in the vicinity of Bandar Shapur. Another prolific structure recently discovered by Anglo-Iranian is the field at White Oil Springs lying between the Masjid-i-Sulamin and Haft Kel fields.

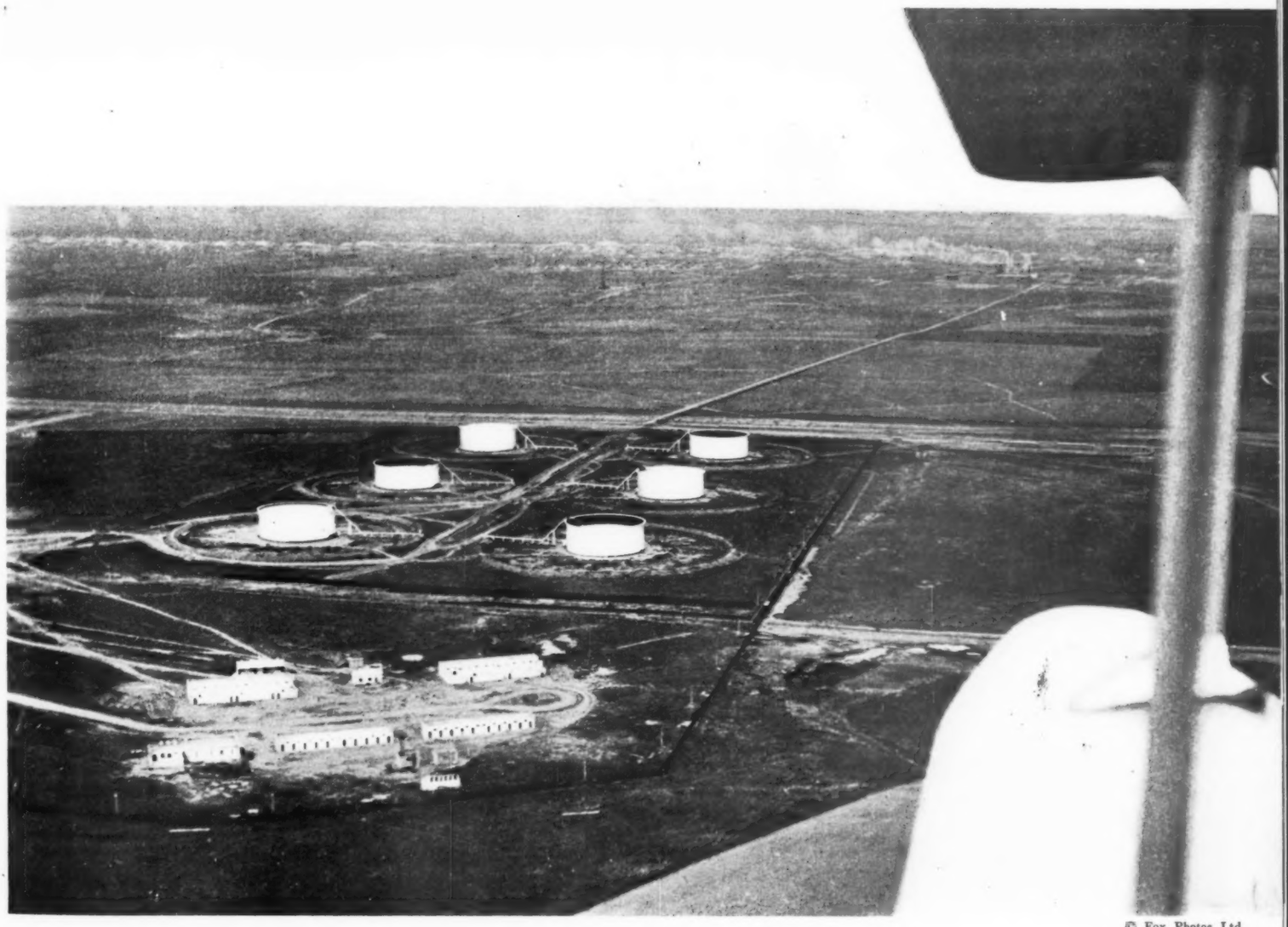


Baba Gurgur the Iraq discovery well blowing in to prove production in the great Kirkuk field.

For many years preceding the World War rival commercial interests of several countries, with more or less open backing by their respective governments, sought to obtain petroleum concessions in the territory west of Iran which then was part of the Turkish Empire's Asiatic provinces. The story of this rivalry has been told many times. It resulted finally in the organization of the Turkish Petroleum Company, a combination of British and German interests, and the grant to that company by the Turkish government of a concession in June, 1914, on the very eve of the war.

The ensuing conflict changed the situation in the Near East completely, erased

Illustrating problems confronting early development of Iraq when the automobiles of the geological parties had to be equipped with automatic rifles.



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The Iraq pipeline running across the desert to pump station and reserve tanks between Haifa and Kirkuk.

Turkey's control over the Arab peoples and led to the setting up of new nations in that part of the world including the Kingdom of Iraq which embraced the territory

A tool pusher mounted on a camel in the early days of development in the Near East.

covered by the original grant to the Turkish Petroleum Company which ultimately became the Iraq Petroleum Company Ltd., the first oil company really international in ownership, with its capital equally shared by British, French, Dutch and American interests.

In 1931, following five years of exploratory work by the company, a new agreement was made with the government of Iraq by which the Iraq Petroleum Company agreed to limit its operations to the vilayets of Baghdad and Mosul lying east of the River Tigris and relinquished its claims to larger areas west of the river. Thus was opened the way for the development of the great Kirkuk field and the building of the 1200-mile bifurcated pipeline across the desert to the eastern shores of the Mediterranean*. In 1937 production from the Kirkuk field was 30,000,000 bbl., giving Iraq eighth place in rank among oil producing countries. While only a small part of the area controlled by the Iraq Petroleum Company has been developed thus far further expansion is dependent upon increased pipeline capacity, plans for which already have been drawn.

When the Iraq Petroleum Company, after its preliminary survey, elected to confine its operations to the area east of the Tigris it left unoccupied a much larger section of the country to the westward. Forty thousand square miles of this territory was taken over promptly by the B.O.D. Company Ltd., a British organization in which investment groups in Italy, France and Germany also were interested. It was known that petroleum deposits existed in this area. German prospectors had found oil at a depth of 150 ft. and the Iraq Petroleum Co. had sunk half a dozen wells in the districts about Qaiyarah, drilled to depths of 1200 to 1800 ft. These also were producers. Nothwithstanding these encouraging showings the Iraq Petroleum Co. selected the area further east for its own

World Petroleum, September, 1932; February, 1935.

Early and modern wells in the Near East; on the left is shown the official spudding-in in 1927 of Palkhanah No. 1 by H. M. the late King Faisal of Iraq, while on the right is modern well No. 58 on Bahrein Island and above is shown the hook-up for a flowing well at Kirkuk.

operations because of the characteristics of the crude. Oil from the western district was of a much heavier base and its high sulphur content necessitated treatment to reduce this before it could go to market.

Development of Mosul oil has been delayed not only by natural difficulties and the nature of the product itself but also by financial difficulties encountered by the owning company in raising the large sums required by the cost of exploration and by its dead rent payments to the Iraq government. In 1937 control passed to interests associated with Iraq Petroleum Company and is held in the same proportions as their shares in that company. The holding company is known as Mosul Holdings Ltd. It owns all but a few shares of Mosul Oilfields Ltd., which in turn controls the operating company, B.O.D. Company Ltd.

The present situation is that very large oil-bearing structures have been located in the Mosul area, a number of wells have been drilled, but the movement of its oil to market awaits the provision of pipeline facilities and solution of the problem of eliminating excess sulphur content on which petroleum chemists are now engaged. That Mosul will play an important future part in supplying the world's steadily increasing demand for petroleum is evident.

Most spectacular of recent developments in the Near East has been the rise of Bahrein to a place of prominence in the world of oil. That small island on the western side of the Gulf of Iran, the very existence of which was hardly known to the western world a few years ago, has become thoroughly familiar through the operations of Bahrein Petroleum Company Ltd., representing the joint interests of Standard Oil Company of California and The Texas Corporation. Though Bahrein is still in the early stages of its development as an oil field it produced 7,762,000 bbl. of oil in 1937 and probably will reach nearly 12,000,000 bbl. in 1938.

Iran, Iraq and Bahrein, with operations limited to a fractional part of the potential oil bearing area of the Near East, produced in 1937 over 15 percent of the whole volume of world oil production outside the United States.

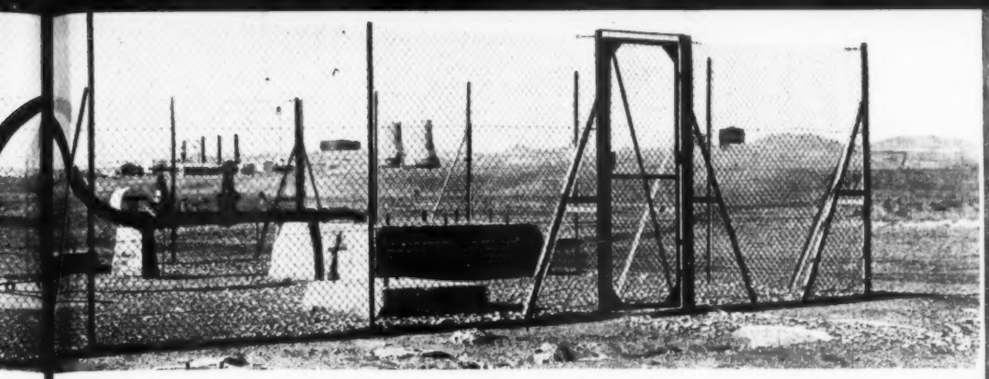
With the demonstration in Iran, Iraq and Bahrein of the vast oil potentialities of the Near East and with the mounting realization of oil's importance as a military and industrial factor a strong movement has been put under way to obtain concessionary rights to all remaining territory east of Suez which offers a reasonable possibility of yielding oil.

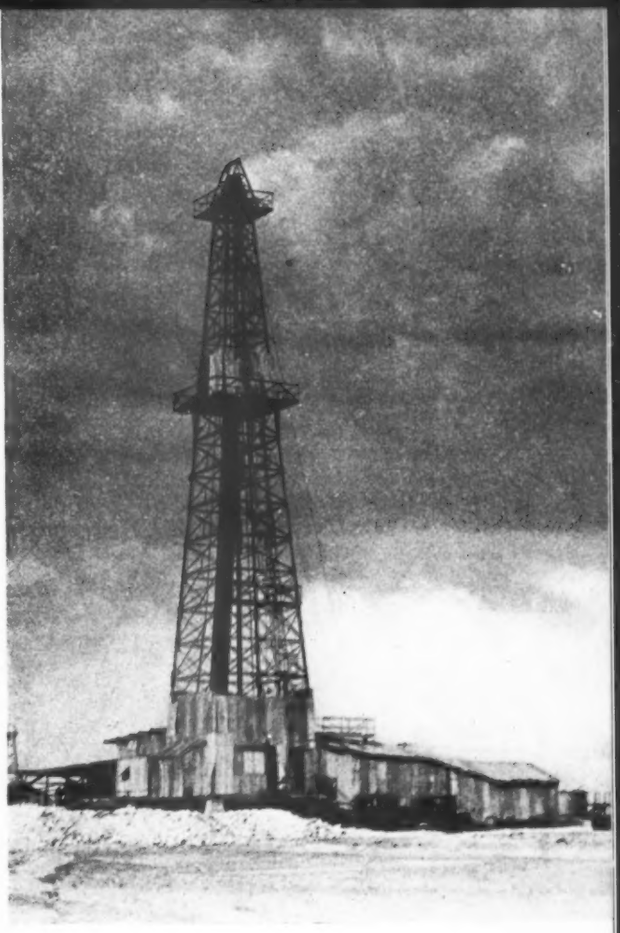
Following their success in locating a highly productive field in Bahrein the interests controlling that field, through the California Arabian Standard Oil Company obtained a concession 150 miles in width along the esatern seaboard of Saudi Arabia. Test wells have shown the existence of at least one prolific field and preliminary surveys indicate the probability of others that may make this part of Arabia another or a greater Iraq.

Between Bahrein and the southern border of Iraq on the shore of the Gulf of Iran is the Sultanate of Kuwait where the Kuwait Oil Company, a joint venture of the Gulf Oil Corporation and the Anglo-Iranian Oil Company, brought in its first producing well early in 1938. This well, the second to be drilled by the company, demonstrates the presence of oil in Kuwait. The extent of the field remains to be determined by further tests, but indications are that it will be a field of major importance.

Meanwhile the interests represented in the Iraq Petroleum Company have been seeking concessions in the areas not already preempted throughout southwestern Asia. A group of companies has been organized to undertake exploration in the principalities and sheikdoms of the Arabian peninsula and along the eastern Mediterranean.

These concessions cover selected areas in each of the districts indicated and form a





broken fringe along the eastern shore of the Mediterranean and the Red Sea and along the Gulf of Iran and the Indian Ocean on the eastern side of the Arabian peninsula. Activity, thus far, has been centered on geological surveys and preliminary exploration which will be followed in the natural course of events by test drilling. Beyond that development will depend, of course, on what may be revealed by the drill, but competent geological opinion holds to the belief that oil will be found in many parts of this territory.

In Northern Egypt, both east and west of Suez, a great intensification in the search for petroleum has taken place within the past year. Half a dozen or more of the largest international companies have obtained concessions and an active drilling program has been started, resulting in the discovery of new production at Ras Ghareb in April 1938. Storage is being erected and a submarine pipeline will be laid to convey this output to the Suez refinery. Egypt has been a producer of 1,000,000 to 1,500,000 bbl. from its one developed field for many years past. A substantial expansion in its output appears probable as a result of the new activities now under way.

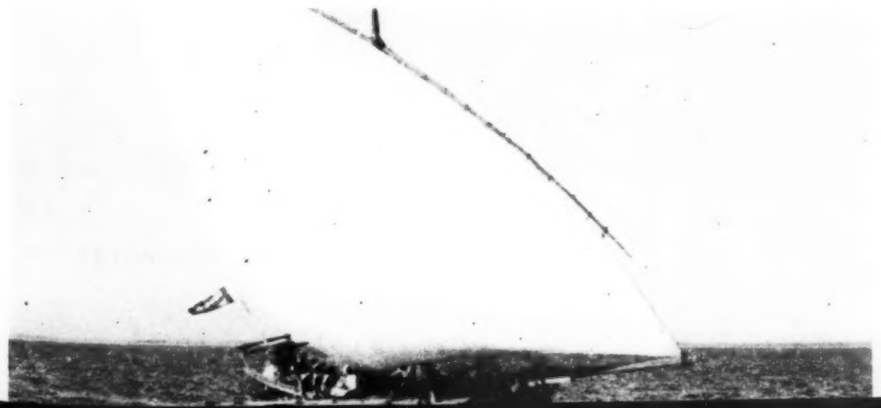
To the eastward of the areas previously mentioned, in northern and eastern Iran and in Afghanistan, exploratory work has been going on during the past year on concessions held by Amiranian Oil Company and Inland Exploration Company, both subsidiaries of Seaboard Oil Company of Delaware. As a result of the surveys that have been run very promising structures have been located in the northwestern part of Afghanistan and in northeastern Iran to southeastward of the Caspian Sea. Owing to the large increase in production in areas advantageously located along the Gulf of Iran and to heavy cost of development and operation in areas far removed from rail and water transportation an agreement has been reached between the holders of the concession and the governments concerned permitting the rights held by the companies to lapse. This involves only a temporary suspension of development in these areas. The fact that the presence of oil has been determined, as nearly as it can be in the absence of drilling, makes it practically certain that drilling activities in this territory will be pushed as soon as world market conditions create a demand for the oil. Both in Iran and Afghanistan the national governments are interested in bringing about the early development of their petroleum resources.

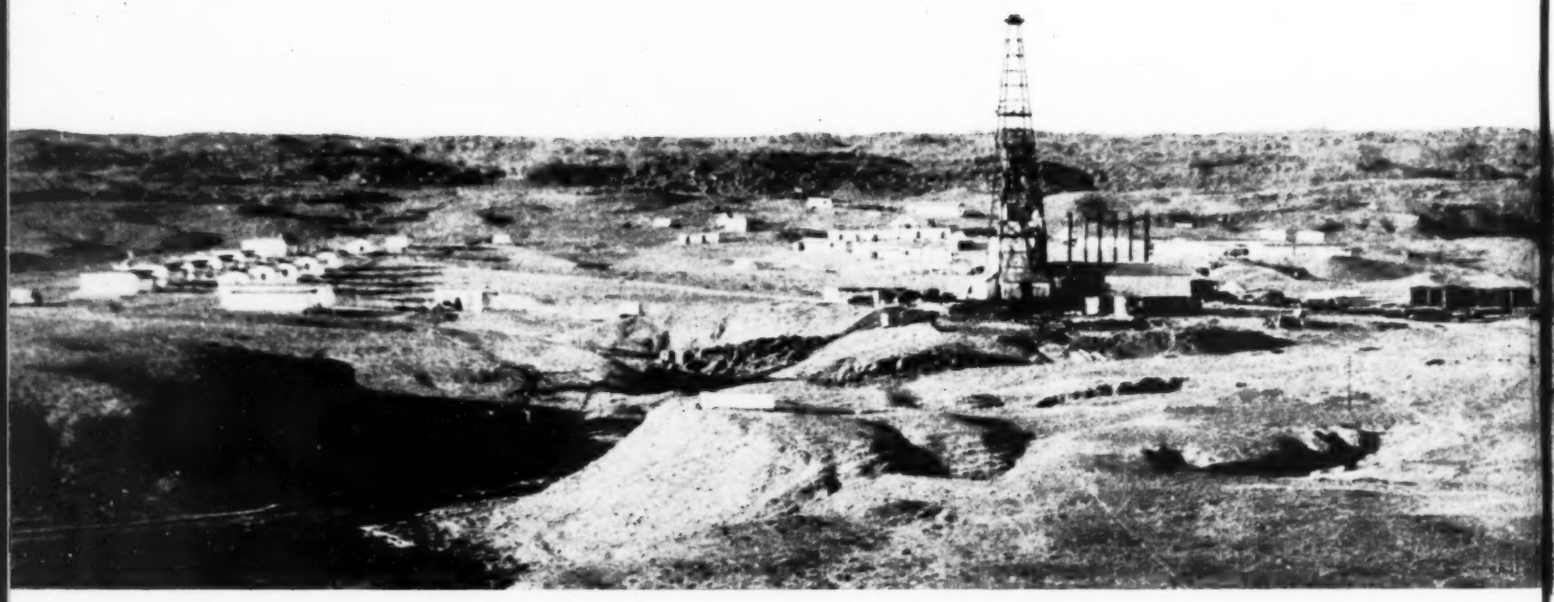
Some forty to fifty years ago, when drilling methods and equipment were far more primitive than they are today, some few shallow wells were drilled in the western provinces of India. Much later the Attock Oil Company Ltd. developed a productive field further north. Now, with prospects of oil in many other areas in this part of the world, it is probable that arrangements will be made for further exploration in India and for more extensive surveys of the northwestern provinces.

North of Syria, along the upper reaches of the Tigris River, the Turkish Government, through its Institute for Mining Research and Prospecting, has drilled a number of wells as part of its systematic search for indigenous petroleum. Though only showings of oil have been obtained thus far this Mardin-Siirt area, lying directly between Mosul and the rich Russian fields of the Baku district, is regarded as having attractive possibilities. Drilling also has taken place further westward in the Silician area and in European Turkey along the Dardanelles. The Turkish authorities are convinced that production will be found at some point within their domain and are determined to continue exploration until a field is located or the possibilities become exhausted. Some drilling is going on in Greece, while in Ethiopia the AGIP, Italian government oil company, is carrying out exploration for oil.

Thus in every part of the Near and Middle East, from Egypt to India and from Turkey on the north to the southernmost reaches of the Arabian peninsula, the movement to expand production and the hunt to locate fresh sources of supply for an oil hungry world is going forward. It is armed with the most ingenious methods of underground mapping and survey that science has been able to devise and with the most improved and up-to-date equipment that man has developed out of his past experience in probing the earth's surface. Surveying, drilling, transport, pipeline and refining equipment in great quantities will continue to move into this area during the next few years. What the outcome will be in particular districts it is impossible, of course, to predict in advance but no one who has made a study of conditions in this part of the world doubts that it will carry the Near and Middle East to a place of first-rate importance among the oil producing regions of the world.

Dhow in full sail on the Persian Gulf along the shores of which intensive oil development is going forward.





KIRKUK—A Field Developed With High Technical Skill

Methods Employed Provide Maximum Recovery Without Waste—Characteristic Formations—Movement of Oil from Wells to Mediterranean Terminals—Company's Provisions for Health and Recreation of Personnel.

RANKING second only to Iran as the most important oil producing area in the Near East is that part of Iraq, lying east of the River Tigris, which for the past ten years has been under development by Iraq Petroleum Company, Ltd. Here, close to the Eternal Fires mentioned in the Old Testament and where petroleum products probably were first utilized by man, is located a highly productive field which from the viewpoint of the technical skill with which it has been developed and equipped might well serve as a model for other parts of the world.

The story of Mesopotamian oil from its earliest discovery down to the completion of the great pipeline which links the producing field to the Mediterranean has been told many times* and need not be repeated here. What has not been told before is the story of Kirkuk field itself, the methods of production employed, and the present operations of Iraq Petroleum Company.

Kirkuk is the only field proven to date by the Iraq Petroleum Company. It lies in northeastern Iraq, approximately 200 mi. north of Baghdad, in the foothill region between the high mountains of Kurdistan and the arid plains of the Tigris and Euphrates rivers.

Geologically, the field is an example of normal anticlinal accumulation of oil. The reservoir rock is a thick porous and fissured limestone ranging in age from Middle Eocene to Lower Miocene and known among members of the company's organization as the Main Limestone.

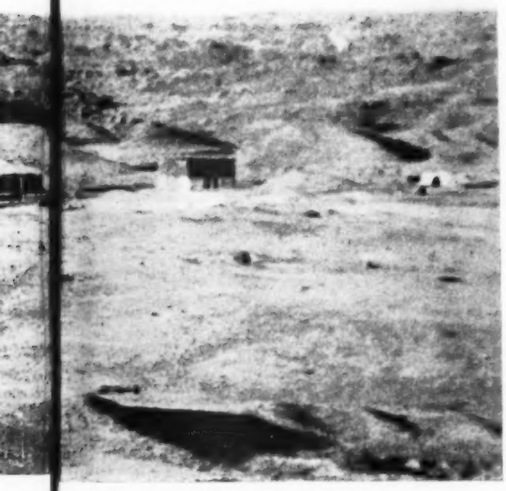
The reservoir formation is underlain by a thick series of Eocene and Upper Cretaceous foraminiferal marls.

A cover about 1,000 ft. thick is provided by the discordant series of Vindobonian age known in the Iraqi-Iranian geosyncline as the Lower Fars. This series consists of rapid alternations of Anhydrite (or gypsum at the surface) red, grey and green silty marls and thin limestones, with rock salt and salty shales in the middle zones only. A thin conglomerate marks the base of the Lower Fars.

In succession above the Lower Fars is the conformable Upper Fars group of red sandstones and siltstones of Mio-Pliocene age passing upward into Bakhtiari conglomeratic deposits of Pliocene and Quartenary age.

The structure of the Main Limestone reservoir is that of an elongated dome of great amplitude, striking NW-SE, approximately 60 mi. long by one to two miles wide. In cross section the anticline is flat topped with asymmetric flanks dipping up to 50 deg. and locally complicated by normal faulting. From SE. to NW. there

*See WORLD PETROLEUM, September 1932; February 1935.



Above, a general view taken some years ago of one of the Iraq Petroleum Company's test wells showing the rough terrain in which operations are carried on. Below, a night view of the highly efficient stabilization plant.

are three domes of decreasing magnitude and importance, viz. Baba Gurgur, Avanah and Khurmala. The oil pool is continuous in the first two for a length of some 50 mi. Gas has been proved in the Khurmala dome.

Considerable discordance exists between surface and subsurface structure, especially on the southwest flank. The Lower Fars beds below the Salt Zone conform to the Main Limestone profile, but in the Salt Zone beds are overthrust to the southwest along reversed fault planes with associated minor features such as isoclinal folding, tectonic thickening or attenuation of incompetent strata. The plastic beds of the Salt Zone accommodate themselves to the discordance between surface and subsurface structure.

Careful study of the sequence penetrated from the inception of drilling has resulted in establishing accurate correlations. More than 30 marker beds are recognized and it is possible to forecast depths at which these will be encountered in any new well with a high degree of precision. Limestone beds have proved of outstanding value.

Although the natural gas fires at Baba Gurgur are of great antiquity the modern history of the field dates from the successful completion of Iraq Petroleum Company's discovery well Baba Gurgur No. 1, which was completed in October 1927 as a prolific producer. Thereafter exploratory drilling was carried on to determine the extent and commercial possibilities of the field and much valuable scientific information was obtained. The length and breadth of the field were defined with level of edge water at a number of chosen points; pressure studies established the existence of a remarkable condition of pressure equilibrium throughout the oil reservoir and in the water zone; saturation pressure studies, bottom hole differentials set up by varying flow rates, subsurface temperature surveys —these and other studies placed Kirkuk field in a unique position for production along scientific lines before the removal of oil began.

To-date 47 wells have been drilled. These cover the length and breadth of the field and are spaced along both flanks with a few located at key positions on the axis. The majority of the wells are producers, actual or potential, and a few wells are sited so as to give control information on the movement of edge water on the perimeter of the field, and to observe dome pressures. Although, as will be shown later, production is not drawn from the whole field at present, pressures and other observations on a requisite number of wells outside the producing area and reaching to the limits of the field are regularly made.

In view of the high angles of dip found in many parts of the field, from the surface downward, and the rapid alternation of hard and soft beds, a steady average drilling speed is maintained. This policy has been amply repaid by freedom from fishing jobs and by obtaining first class completions. Apart from the two somewhat unusual conditions given above, drilling presents no serious difficulties and intelligent control of circulation permits of penetration to the requisite depths in the reservoir limestone without serious losses of fluid.

In the absence of problems calling for more modern equipment and in view of the comparatively shallow depths to be drilled (maximum 4,000 ft.) the original exploratory equipment is still in use for the present single string drilling program.

Steam is still favored because of its flexibility. Water and fuel supplies present no difficulties.

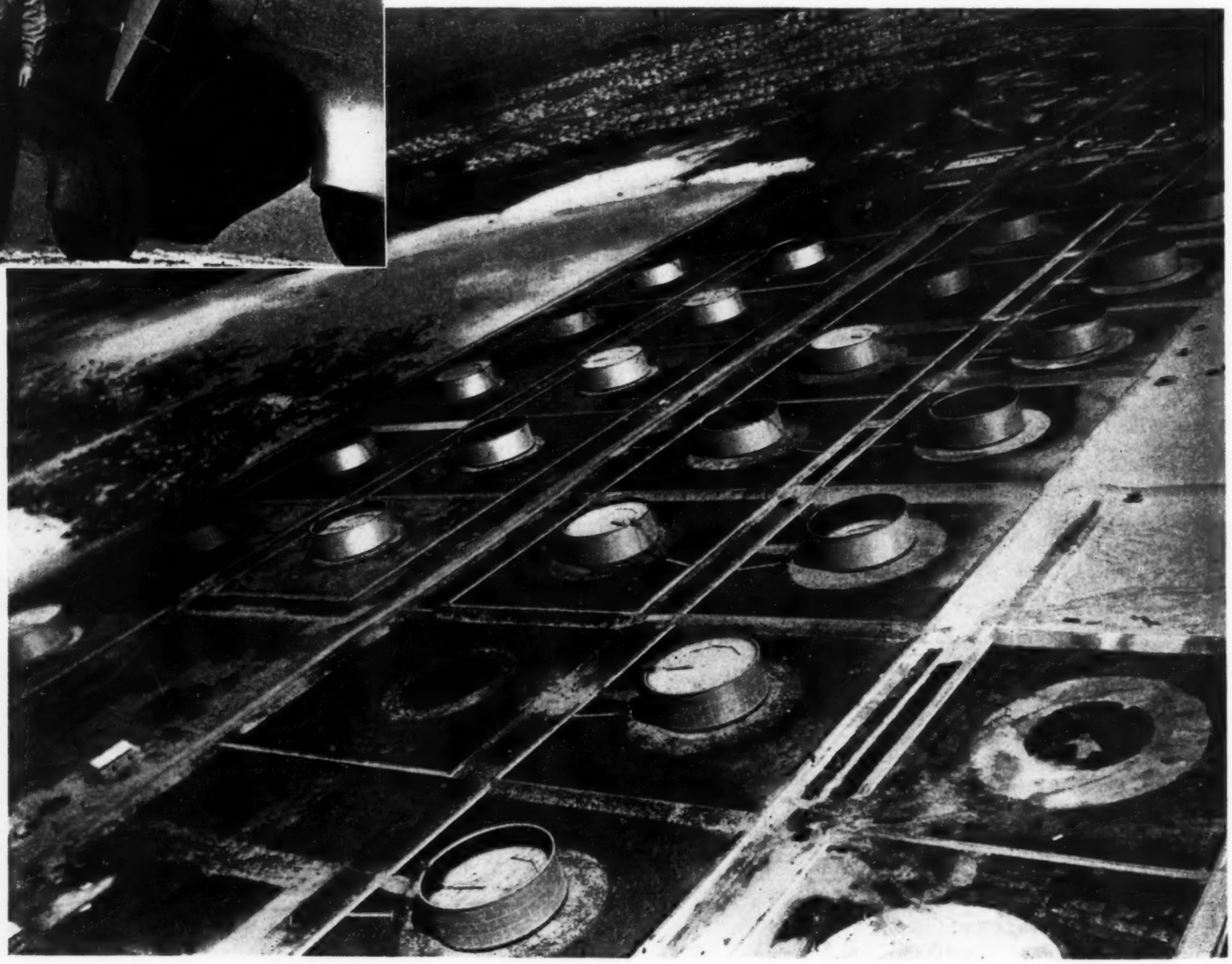
One of the planes belonging to the I.P.C. and oil storage tanks at Haifa.

© Fox Photos Ltd.

excavated with one side completely open, giving easy access and quick drainage in the event of an emergency.

A 20½ in. rock bit is run on eight inch drill pipe to depths of 150 to 300 ft. when 16 in. A.P.I. casing is run and cemented to the surface. Drilling is then resumed using 14⅞ in. bits and 6 in. drill pipe, progress being rapid when penetrating the Upper Fars formation. This part of the hole is drilled usually with pilot fish-tail bits. On entering the Lower Fars, however, rapid alternations of hard and soft rock necessitate frequent round trips with rock and shale bits and speed is correspondingly reduced. A few cores are taken to check important key beds, but the position of most markers is identified from cuttings. A string of 11¾ in. A.P.I. casing is run and cemented up to the 16 in. shoe at the top of the Transition Zone, usually before meeting any oil-bearing limestone. Below the 11¾ in. shoe, four in. drill pipe and 10½ in. bits are used. Some 300 ft. of hard anhydrites and limestones is drilled with rock bits until the top of the Main Limestone is reached. The next step is cementing of 8⅝ in. A.P.I. casing.

Drilling in the Main Limestone is done with rock bits and core barrels. A varying amount of open hole is drilled dependent on the permeability of the limestone. This is readily shown by circulation losses during drilling or on application of pressure.



Drilling practice has become standardized and a brief description of a typical well explains all points of interest.

Drilling Equipment Used

Derrick	122 feet by 24 feet base.
Engine	11 in. by 11 in. horizontal twin.
Draw works	Three speed.
Rotary	24 in.
Slush pumps	14 in. by 7 in. by 18 in.
Boilers	5—40 h.p. 140 lb./sq. in.

The location for drilling is selected, as far as geological considerations permit, to allow drainage of surface water. Cellars are

Rock pressures in the Kirkuk field are such that easy control with circulating fluid is possible. The oil-bearing formation is in a state of pressure equilibrium making it a simple matter to calculate the pressure likely to be encountered at any subsurface contour. Thus the weight of fluid required to exert a pressure equal to that in a given stratum is a function of surface elevation and depth. Dependent on these the weights of fluid used vary from 80 lb. per cu. ft. in

the case of shallow wells with low surface elevation to that of water, fuel oil or even crude in the case of deep wells with high topographic elevation. In every instance the objective is to avoid circulation losses and at the same time effectively to remove all cuttings. Reversed circulation with oil is occasionally used to clear all suspended cuttings from the hole immediately before completion.

In a few instances pressure drilling, using oil circulation, flush-joint drill pipe and simple triple deck stuffing box has been employed.

As a result of the accurate pressure balance obtainable it is common for a well to be drilling in permeable oil-bearing limestone with only minor losses of fluid and no suggestion of pressure or sign of oil on the ditch.

When it is desired to bring in a well, drill pipe is withdrawn, the master gate closed and surface connections installed. During this interval the well usually builds up a pressure. Where the well head is situated on high ground it is occasionally necessary to bail a little until fluid begins to rise.

Standard practice is to drill open hole in the Main Limestone for the minimum distance required to obtain good producers, except where reasons exist for drilling deeper.

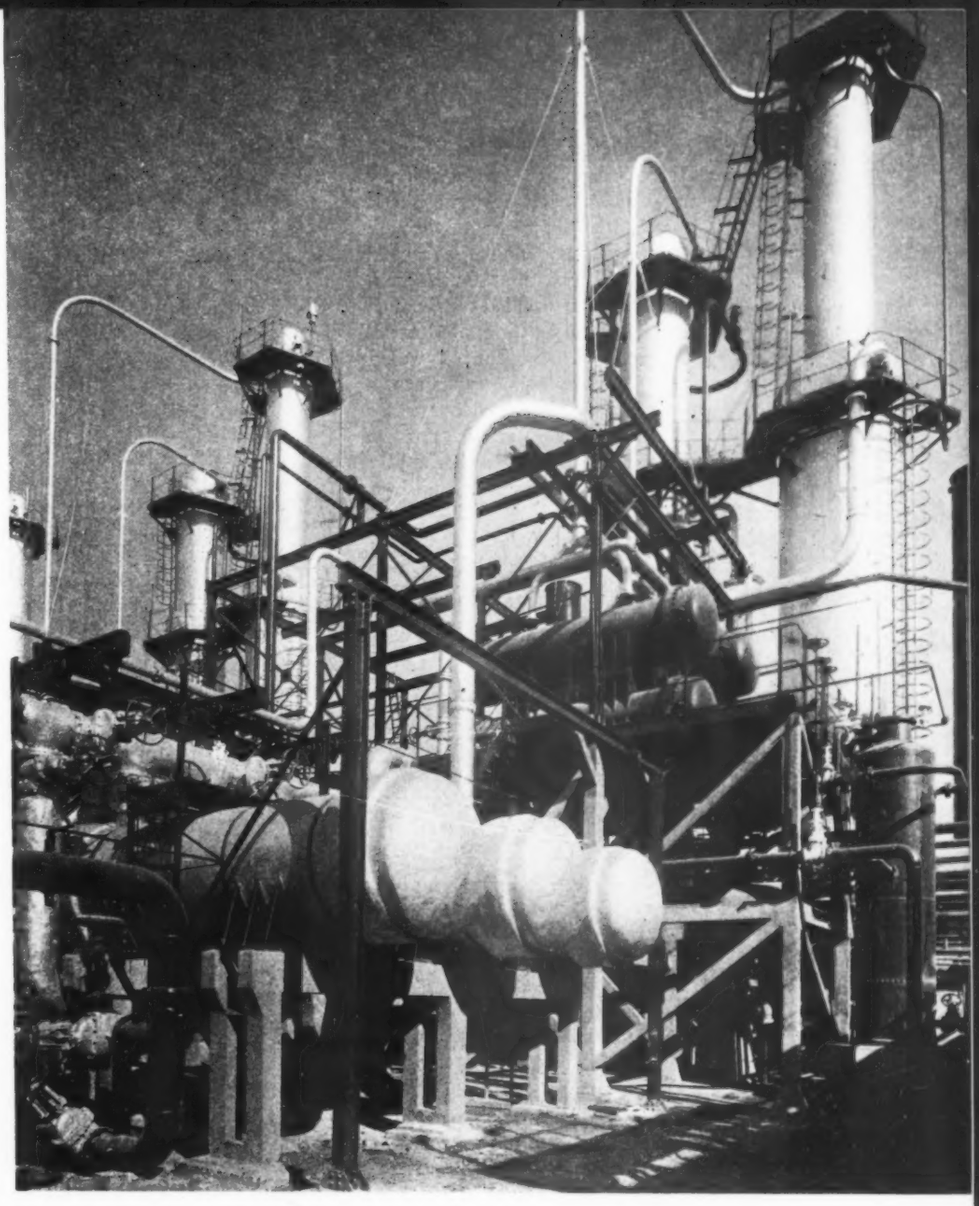
Recording weight indicators are used during drilling and deviation surveys, using the acid bottle method are carried out at regular intervals.

An average well takes three months to drill.

The production technique best employed in a limestone field of the Kirkuk type is in marked contrast with that usually adopted in sand fields. It is unnecessary to drill wells at close intervals or according to a regular pattern based on lateral extent of drainage. In producing oil from the Kirkuk field the effect on the whole reservoir is studied as well as any local conditions that may be set up. The high degree of effective permeability in the limestone has been previously mentioned. Observation wells 30 miles distant from the nearest point of oil removal are affected thereby.

In preparing the field for production, therefore, it was decided that in order to observe the effects of removing 30,000,000 bbl. per annum from the reservoir, the initial scheme should aim at taking oil from a rectangular area, roughly 10 mi. long by two miles wide, astride the crest maximum at Baba Gurgur and covering both flanks. Certain wells inside this area and others spaced on either flank to the ends of the field were at the same time set aside for observation.

The immediate economics of such a scheme are obvious, but at the same time the off-take per unit of area in the 20 sq. mi. concerned was very small and it was furthermore believed that should it become apparent, after a period of production, that the production area required extending, the fluid control of the reservoir would have been revealed in the meantime. There would thus be available additional data on which to base such an extended production scheme.



Heat exchangers, condensers and reflux tank of the stabilization plant.

About 105,000,000 bbl. of oil have been produced up to the present time and the fact that it has not been found necessary to modify the production scheme bears ample testimony to the soundness of the original conception.

Production control, expressed in the simplest way, aims at maximum conservation of the natural energy. This is achieved by close observation of the oil water level and of gas/oil level as the latter is formed at the crest maximum, ensuring that these interfaces move as horizontal planes, and also by checking that the rate of withdrawal from any well does not locally lower the pressure to the point where gas is evolved from the oil in the formation. Stated in another way, flowing pressures at the shoes are always well above saturation pressures, so that the liquid phase is ensured. Indeed in most instances, oil has reached a point high up in the casing before the first bubble of gas is evolved. With these conditions satisfied it follows that gas/oil ratios are entirely dependent on surface installations and atmospheric temperatures.

Fifteen wells are connected as producers, five serving each of three degassing stations. Flow heads are extremely simple. Above the master gate is a Y piece which permits the running of instruments into a well during flow. From the lateral branch of the Y piece a six-inch long radius bend is installed to reduce friction. Then follows a variable beaning device and a flow line of four, six, or eight inch Victaulic pipe laid along the surface to the degassing station. Pressures are recorded on either side of the bean.

Each well has a completely independent

flow line to the degassing station. Here the oil/gas mixture is separated out. Originally the pressure was dropped to atmospheric in two stages, the first stage through vertical type separators and the second stage in 12,000 bbl. gas tight tanks, from which low pressure gas was led off through 16 in. ducts. These tanks were sited at all the degassing stations so that oil would flow by gravity to the pipeline tanks at the first pumping station, two to four miles distant. Oil flowed in and out of the tanks continuously and oil levels were checked by means of Pneumercator gauges set up in a small control house.

Since the construction of the stabilization plant, a full description of which was published in June, 1937, in a supplementary number of WORLD PETROLEUM, the operation of the degassing stations has been modified. The stabilization plant is sited at a point topographically lower than the degassing stations and the oil, after separation of gas at about 50 lb. in the vertical separators, flows to the plant with remaining gas in solution. In other words the plant receives crude with a vapor pressure of 50 lb. per sq. in.

The layout of each degassing station is designed to permit individual testing of wells at any time.

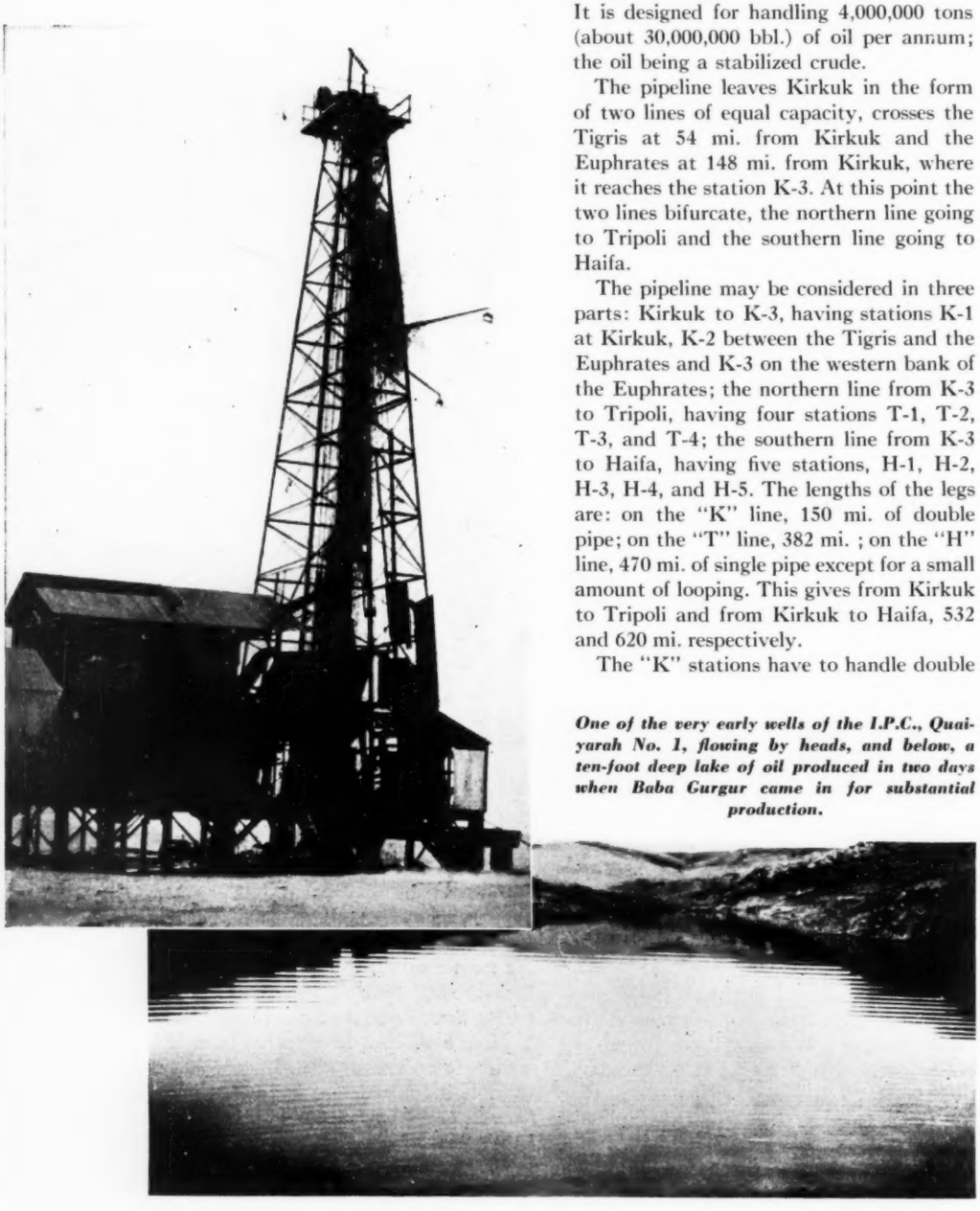
PIPELINE

The company's pipeline takes the oil from Kirkuk to the loading terminals at Haifa and Tripoli, on the Mediterranean. It is designed for handling 4,000,000 tons (about 30,000,000 bbl.) of oil per annum; the oil being a stabilized crude.

The pipeline leaves Kirkuk in the form of two lines of equal capacity, crosses the Tigris at 54 mi. from Kirkuk and the Euphrates at 148 mi. from Kirkuk, where it reaches the station K-3. At this point the two lines bifurcate, the northern line going to Tripoli and the southern line going to Haifa.

The pipeline may be considered in three parts: Kirkuk to K-3, having stations K-1 at Kirkuk, K-2 between the Tigris and the Euphrates and K-3 on the western bank of the Euphrates; the northern line from K-3 to Tripoli, having four stations T-1, T-2, T-3, and T-4; the southern line from K-3 to Haifa, having five stations, H-1, H-2, H-3, H-4, and H-5. The lengths of the legs are: on the "K" line, 150 mi. of double pipe; on the "T" line, 382 mi. ; on the "H" line, 470 mi. of single pipe except for a small amount of looping. This gives from Kirkuk to Tripoli and from Kirkuk to Haifa, 532 and 620 mi. respectively.

The "K" stations have to handle double the throughput of any single "T" or "H" station, and, hence, have six sets of pumps and engines installed, as against three at each station on the two single lines. Each set, consisting of a pump and engine, is built to handle 1,000,000 tons (about 7,500,000 bbl.) of oil a year with a working pressure of 800 lb. per sq. in. nominal. Between stations the pipeline consists of a short length of 10 in. line leading out on the high pressure side of a station, followed by a longer length of 12 in. line.



One of the very early wells of the I.P.C., Quaiyarah No. 1, flowing by heads, and below, a ten-foot deep lake of oil produced in two days when Baba Gurgur came in for substantial production.

© Underwood & Underwood.

Typical of the East is this ox-powered irrigation water wheel.

Three makes of Diesel engine have been installed: on the "K" line, Sulzer; on the "T" line, Werkspoor; on the "H" line, Harland & Wolff. All forty-five pumps are from Worthington-Simpson Ltd. All the engines are nominal 500 h.p. rating. This allows them to work well within their capacity.

A minimum amount of tankage has been placed on the line. Every station has at least one 30,000 bbl. balancing tank, but K-3 has five 97,500 bbl. tanks to permit of a certain amount of elasticity of handling of oil through the northern and southern lines, and of accurate gauging of the inputs to each of these lines. The smaller tanks have fixed roofs. The larger tanks have Wiggins pontoon type floating roofs.

The construction of the line was unusual in that much the greater portion lies in desert country, the only railheads available being at Kirkuk at one end of the line, at Baiji some 66 mi. from Kirkuk, at Homs 53 mi. from Tripoli and at Mafrak 80 mi. from Haifa. There were thus intervening stretches of 413 mi. between Baiji and Homs, and 474 mi. between Baiji and Mafrak, where all transport had to be by motor across desert country. The company was fortunate in being able to solve the water problem at the stations in this desert country by finding near all of them reasonable quantities of water at no very great depths.

Another unusual condition lies in the section between pumping station H-5 and Haifa. Between H-5 and Haifa the terrain rises to a peak elevation of 2,800 ft. and

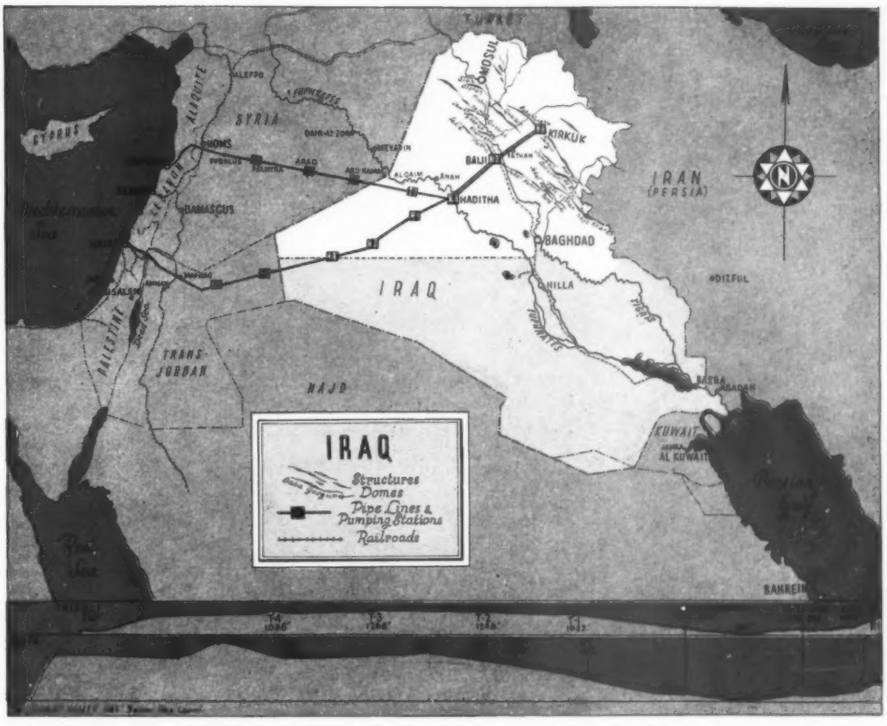
then drops into the Jordan Valley 780 ft. below sea level, rising again over a peak of 760 ft. before dropping finally into Haifa. It was possible so to grade sizes of pipe through the Jordan Valley vicinity that reasonable working pressures are never exceeded in the Jordan Valley itself. However, if the flow of oil should cease for any reason, a static head of 3,580 ft. can be built up in the pipeline at the bottom of the Jordan Valley. To take care of this, relief tanks were placed there, separated from the line by two forms of safety device in parallel. One of these is a spring loaded safety valve and the other is a safety valve of the bursting disc type. These are so set that if the pressure rises unduly in the Jordan Valley, relief is given into the tanks. A small pumping installation is placed near by so that when the line has been started up again, the oil relieved to the tanks may be again injected into the pipeline.

TERMINALS

At Haifa two 12 in. steel pipelines run out some 4,200 ft. on sea bottom into Haifa Bay (each having twin 8 in. flexible hoses) to service two submarine loading berths. The depth of water at these anchorages averages 50 ft. Shore pumping facilities provide for a maximum loading rate of 1,000 tons (7,500 bbl.) per hour. A radio station is situated at the terminal and wireless contact is made with each tanker, 48 hr. prior to arrival, thereby enabling instructions to be transmitted advising whether loading is to be effected at Haifa or Tripoli terminal. Communications between shore and ship are established by telephone connection to each berth in addition to the usual visual methods of signaling. All tankers are moored and connected up under the direction of I.P.C. mooring masters. During 1937 shipments totalled 1,900,650 British tons and 196 tankers were loaded, the average loading rate being 782 tons per hour.

An oil dock has been constructed in Haifa Harbor and dredged to 33 ft.: two berths will be commissioned during 1938.

At Tripoli three submarine berths are available, in an average depth of 50 ft. of water, and are each equipped with two 12 in. steel pipelines on sea bottom, each pipeline having one 8 in. flexible hose. Loading is by gravitation and the maximum loading rate achieved to date has been 1,360 tons an hour. Mooring and connecting up to tankers is directed by I.P.C. mooring masters as at Haifa terminal: similarly shore/ship communications are established by telephone connection to each berth as well as by the usual visual signals. Shipments in 1937 totalled 2,027,000 British tons, involving 170 tankers: the average loading rate for the period was 924 tons per hour.



Above, map of the pipeline, formations and concession of the I.P.C., while below is shown a company guard beside one of the great storage tanks at Haifa where recent disturbances show the wisdom of such precautions.

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The company pays the Iraq Government a royalty of four shillings (gold) per ton of oil won and saved, and a sum of £60,000 (gold) on the first 4,000,000 tons (31,000,000 bbl.) on which royalty is payable and of £20,000 (gold) and pro rata on each subsequent 1,000,000 tons, in commutation of taxation. The gross amounts payable to the Iraq government under these heads for the year 1937 were £820,421 (gold) and £62,042 (gold) respectively.

Further, the company pays to the government of Palestine 2d. a ton on every ton of oil loaded at the Haifa submarine lines, and will pay 5d. a ton on every ton of oil loaded at the Haifa oil dock, when that comes into use, subject to a minimum of £30,000 a year. It pays to the Government of the Lebanese Republic the approximate equivalent of 2d. a ton on every ton of oil loaded at the Tripoli submarine lines.

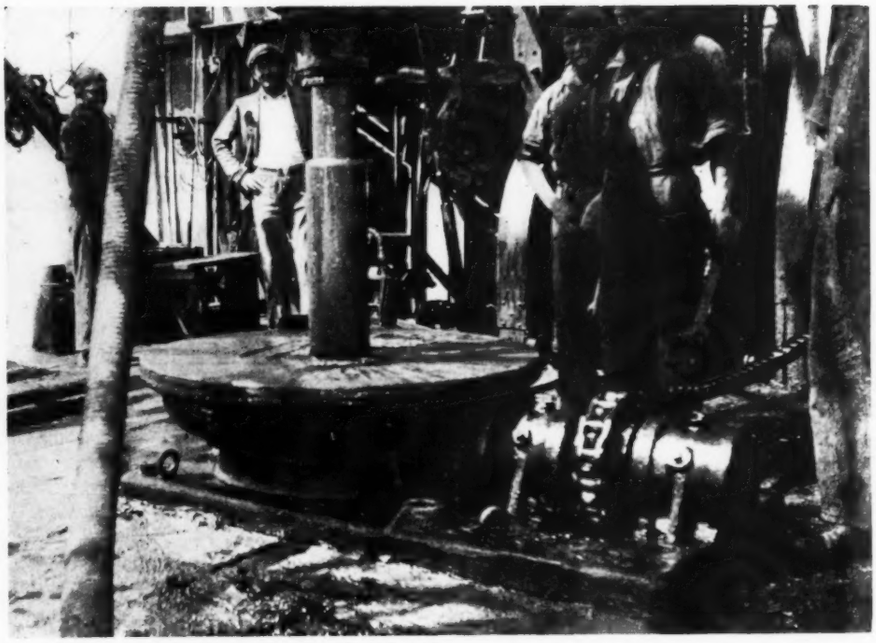
PERSONNEL

The number of employees on the payroll varies according to the amount of construction work in hand; at fields it is at present in the neighborhood of 1,600, and the pipeline and terminal loading stations give employment to some 3,400. Of these 5,000, under 300 have been recruited in Europe or the United States for posts, for which owing to lack of oilfield experience or specialized training, it has not been possible to recruit locally.

(Continued on page 124)

MOSUL Oil Presents Technical Problems

Extensive Structures Located in B.O.D. Concession but Oil Requires Special Stabilization Treatment—Many Shallow Wells Drilled—Deeper Tests Proceeding in Search for Lighter Crude.



Rotary equipment and drilling crew in action near Qasab in the area being exploited by B.O.D. Co., Ltd.

In March, 1925, the Government of Iraq granted to the then Turkish Petroleum Company a concession over the vilayets of Baghdad and Mosul. The conditions of the concession were found to be unsatisfactory both to the government and to the company, and six years later the terms of the concession were revised. In accordance with this revision, the Iraq Petroleum Company (which name the Turkish Petroleum Company had assumed in 1929) surrendered that portion of the two vilayets which lay West of the River Tigris.

In April, 1932, the Government of Iraq granted to B.O.D. Company Ltd., a concession over all the lands of Iraq situated West of the River Tigris and North of the thirty-third parallel. And in November, 1932, Mosul Oil Fields Ltd. was formed to acquire and hold the share capital of B.O.D., B.O.D. remaining as the operating organization.

After passing through a number of vicissitudes, control of Mosul Oil Fields and its operating subsidiary was acquired in March, 1937, by interests closely allied to those in the Iraq Petroleum Company, although the two remain as separate entities. Prior to the change in control a geological survey had been run and a number of wells had been drilled in the vicinity of Qaiyarah. During the past year the activities of the company have been increased and extensive structures have been outlined; but the obstacle to the successful development of the fields has not been removed.

This difficulty is in the character of the oil itself, which is heavy and of such a high sulphur content that some method of treatment not yet perfected will be necessary before it can enter the world's markets on a competitive basis. This problem is believed to be the subject of study by technical experts at the present time.

To the layman it seems remarkable that there should be such a great difference between the product of two fields which geographically are so close together. The fact remains that Mosul crude not only is much heavier than Kirkuk crude but also has a much greater excess of sulphur. It remains to be seen whether science can discover any method of overcoming this handicap.

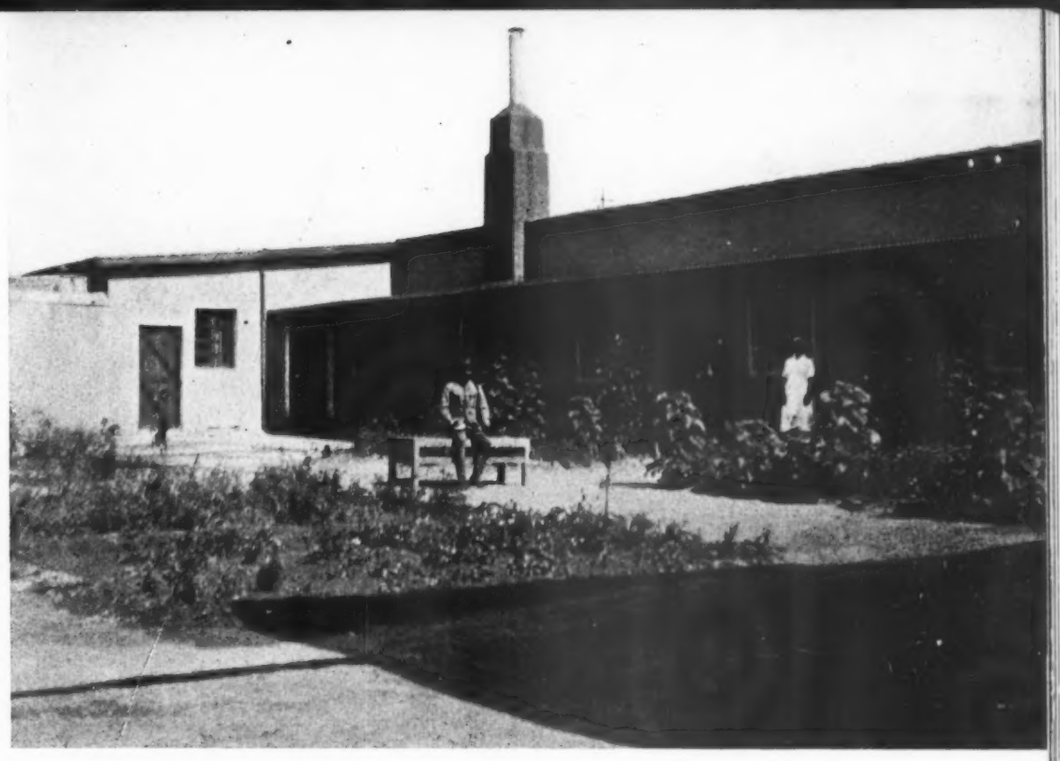
The B.O.D. concession covers an area of about 46,000 sq. mi. There are numerous surface indications of oil within the concession area, mostly in the form of heavy bitumen. Some of these bitumen seepages are large, especially at Qaiyarah, in the Hit area, and in the Fathah gorge. There are marked and considerable changes in the

facies development, with changes of sedimentation and consequent varying underground oil conditions. The rocks so far explored on the surface and in wells extend from Miocene down to Triassic and Palaeozoic but, to date, only the Asmari limestone horizon and a certain Cretaceous horizon (Maestrichtian) have proved of any importance.

Until recently drilling activities were chiefly concentrated on the large anticline of Qaiyarah-Najmah-Jawan on which, to date, 54 wells have been drilled. This structure is some 23 miles long and 2½ miles wide. Its main productive horizon is in the Asmari limestone which is characteristic and has yielded considerable production in other parts of the Mesopotamian geo-syncline. The wells in this structure are low pressure wells, with an average depth of some 1,000 ft. The search for oil from the Asmari horizon was extended to the Qasab structure to the north of Najmah, but the results were disappointing.

Of the deeper tests which have been put down in the hope of finding lighter oil, the deepest is at Qalian which is already below 7,000 ft. Another exploration well is in process of being drilled on the large Makhul structure, which is a continuation of the larger Jebel Hamrin, the two structures being cut by the River Tigris at the famous Fathah gorge. Other deep tests have been made at Alan, Gusair and Ain Zalah in the north, and at Hibbarah and Sadid to the south of Qaiyarah.

Altogether 17 structures have so far been tested, and the total depth drilled to date is 147,350 ft.



The present hospital serving Qaiyarah camp in the concession held by Mosul Oil Fields, Ltd.

Drilling operations are carried out principally with modern heavy rotary equipment, the drilling engines being of Diesel design and of as much as 400 h.p. per rig. The provision of water for drilling in desert country is always a serious problem. In this part of Iraq it involves the construction of lengthy water pipelines from convenient pumping stations on the river. Owing to the great seasonal variation of the level of the river, certain of the pumping stations have had to be installed on floating barges. In certain areas it has been possible to obtain sufficient gas for drilling purposes from shallow formations.

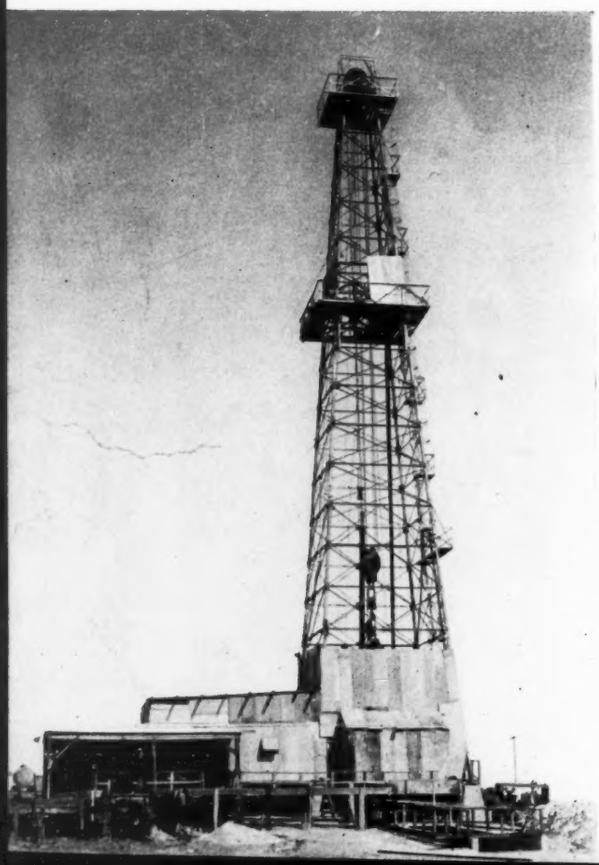
Qaiyarah is well placed as a main camp, containing well-constructed bungalows for both European and native staff, an attractive club building with a swimming pool which has proved a great boon during the intensely hot Iraq summer, and a well equipped hospital which extends its benefits to other than company employees. The bungalows of mud brick at the outside locations are both cheap and effective.

The company is fortunate in that it can obtain all the labor which it requires from two influential Sheikhs who are wise enough to realize that good service must be given in exchange for good wages.

The main camp of the B.O.D. activity at Qaiyarah in the great oil area west of the Tigris.

BAHREIN Field's Remarkable Characteristics

Ideal Features of Low Cost Production Close to Tidewater Now Enhanced by Discovery of Deeper Zone Below 4,000 Feet Adding Greatly to Potentialities.



LYING close to the shore of Saudi Arabia, in the western part of the Gulf of Iran, the independent Sheikdom of Bahrein is small in area. The principal island of the group, Bahrein, is some 12 miles wide and 27 miles in length. The other islands are much smaller. Until the past few years its principal industry has been pearl fishing. Its ruler, Sheik Sir Hamad bin Isa Al Khalifah, is recognized as one of the most able and progressive rulers in the Near East.

When the Iraq Petroleum Company was organized it was stipulated that the constituent companies should not engage in petroleum exploitation on their individual account within an area specified in an agreement signed by the companies. At that time Gulf Oil Corporation held a petroleum concession on Bahrein, but since the company was one of the American group having a joint holding of a 23.75 percent interest in Iraq Petroleum and since Bahrein was within the area barred to this group the Gulf interests felt themselves obliged to withdraw from operations there.

Accordingly, in 1931, the Gulf Oil Corporation transferred its rights in Bahrein to the Standard Oil Company of California. Through a subsidiary, Bahrein Petroleum Co. Ltd., the California company started a program of exploration and development. A geological party reported favorably on the area, then drillers and equipment were sent out from San Francisco and a temporary camp was established.

Jebel Dukhan, a height rising 450 ft. above the surrounding plain, was selected on surface geological information as the site for the first test. Cable tools were used in drilling and the first well, Jebel Dukhan No. 1, came in for 100 bbl. hourly at a depth of 2,008 ft. in June, 1932. Well No. 2 followed soon afterward with a flow of about 1,500 bbl. daily from approximately the same depth. Later, a combination rig was installed in order to carry on deeper drilling and tests were made in all directions and far from the original location.

By the middle of 1934, six wells had been drilled and it was demonstrated that the field was capable of sustained production over a large area. To provide facilities for handling the output of the wells, a steamer load of equipment and a party of construction engineers was sent out from San Francisco. A loading terminal was constructed on Sitrah Island, a short distance from the shore of the main island across shallow water. There is an eight-inch pipeline six miles long from the producing area to shore, and six submarine lines three miles in length and ranging from eight to twelve inches in diameter from shore to the loading wharf. The loading wharf will berth two tankers with 50 ft. of water at low tide. The loading capacity ranges from 1600 to 4800 bbl. hourly for the various products. The pipelines on shore are laid partly above ground and partly in trenches, depending upon soil conditions. The above ground sections are supported by anchor blocks of masonry and bends are provided to allow for expansion and contraction due to changes in temperature. Under the present system the crude oil flows from the wells through two, three, four and six inch lines

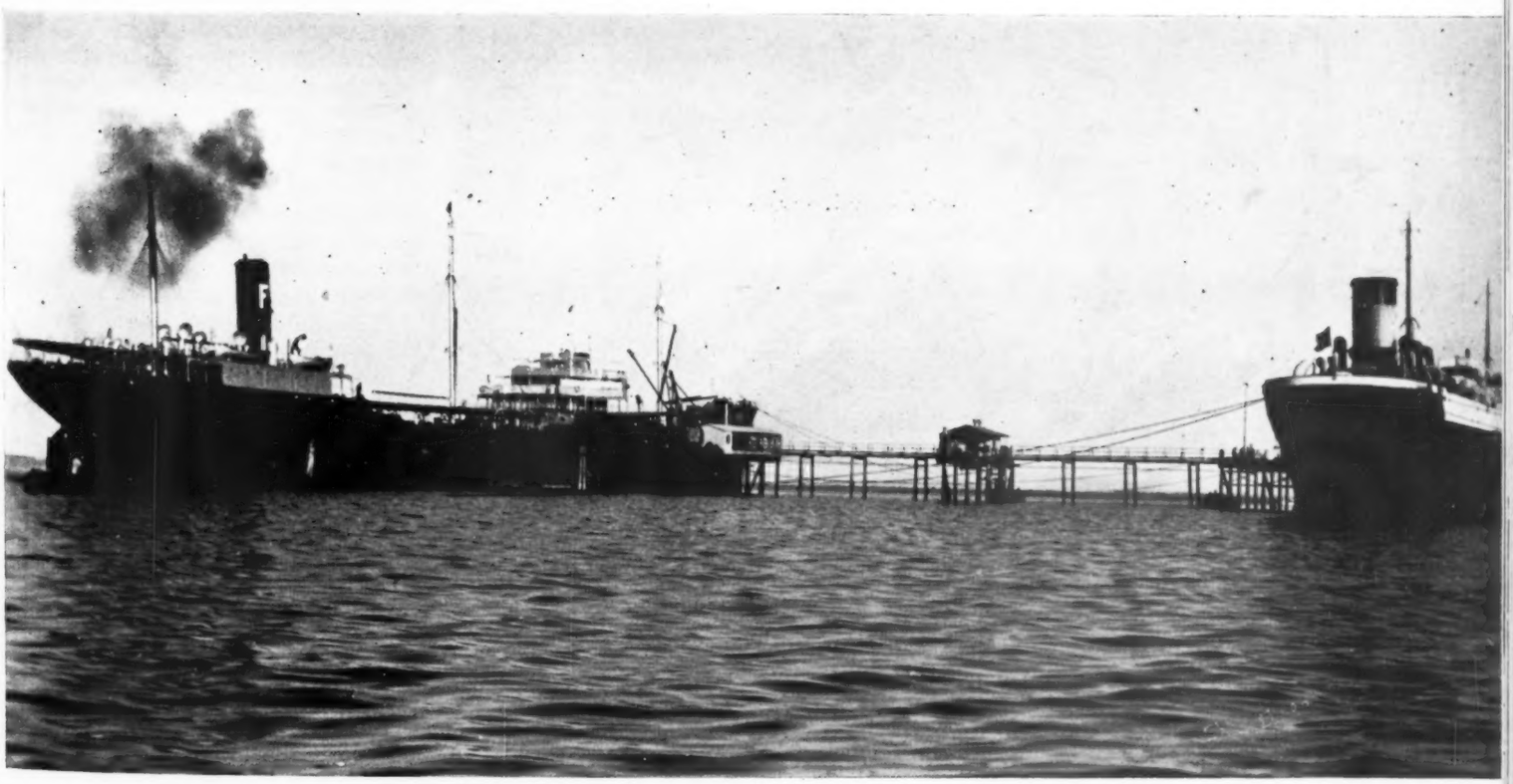
On top of the facing page is shown a gauger on top of tanks on Bahrein island, while on the same page below may be seen one of the wells—No. 58—which fill these tanks. On the bottom of this page is shown two tankers being loaded with products from Bahrein over the wharf at the end of the submarine pipeline. Life on Bahrein is pleasant in spite of the heat of the Persian Gulf; to the right is one of the modern air-conditioned houses built for employees and directly below is the Pool of Virgins at the northern end of the Island.

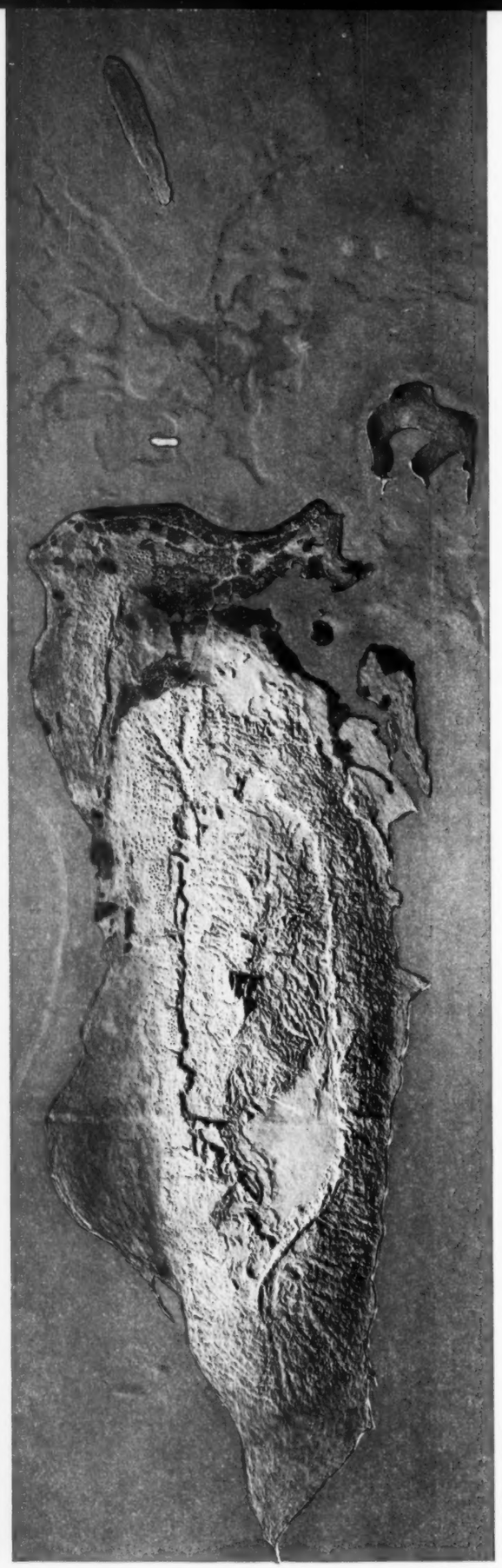
to the five gathering stations where the crude is degassed and where pumps are installed to pump it to storage tanks at the refinery. The refined products are pumped from the refinery through five pipelines ranging from eight to sixteen inches in diameter to the Sitrah loading terminal, a distance of three miles.

Shipment of crude oil began in 1934, and the growth of activity can be measured by the increase in production shown in the accompanying table.

BAHREIN CRUDE PRODUCTION

1932	902
1933	31,376
1934	285,072
1935	1,264,808
1936	4,644,635
1937	7,762,264





Airview of Bahrein Island surrounded by the waters of the Persian Gulf.

Plans for a refinery were begun as soon as it was evident that production would justify the operation of a refining plant. Construction of the refinery was begun in 1935. Originally it was designed for a capacity of 10,000 bbl. but as more and more wells were brought in the plans were revised to provide for 25,000 bbl. daily capacity. The refinery was completed and put into operation late in 1937.

Meanwhile drilling has gone steadily forward and to date 50 wells have been completed to the main pay, all but two of which are producers. The proven area amounts to about 12,000 acres and the wells are spaced one to 180 acres. Average initial potential per well is about 7,000 bbl. daily and average depth is about 2,150 ft. The crude is of good quality with an API gravity of approximately 33 deg.

The drilling history of the field is of interest because of the variety of problems encountered. Many types of drilling equipment have been used and all common drilling methods have been experimented with in an effort to overcome an unusual combination of difficult drilling conditions. Three strings of casing must be run in wells drilled to the 2150-ft. main pay and five strings in wells drilled to the 4500-ft. pay which was recently discovered, and all but the surface casing must be well cemented. The fastest and cheapest drilling method has been found to be to drill the entire hole with rotary using rock bits. The limestone, shale, chert, sandstone, and anhydrite formations encountered are not particularly hard, but drilling progress is greatly retarded by such difficulties as the following: loose boulders; 1300 ft. of cavernous limestone in the upper part of the hole in which no circulation can be maintained; tar pockets which stick the drill pipe; gas, oil, and water zones which must be mudded off with weighted mud; a cavity below the main pay in which all returns are lost and cannot be regained, and from which tremendously large volumes of hot salt water flow; a 1500-ft. section of porous water-bearing limestone through which it is very difficult to maintain the hole and mud in proper condition because of mud ringing and related problems; and finally the recently discovered 600-ft. section below 4000 ft. which carries gas at 2,000 lbs. pressure, water, and oil. Additional difficulties arise in attempting to obtain cores of the soft pay limestone, in making formation tests, and as a result of unusually high rock temperatures.

Drilling-in through the main pay under pressure with rotary, circulating oil and flowing against back pressure, has been entirely successful. Thick shale bodies have been penetrated without caving, the location and capacity of the several pays are accurately logged, and, most important, the mudding off of pays is definitely prevented. It was found that drilling-in under pressure with cable tools was slow or impossible because cuttings could not be bailed or flowed off bottom when drilling between pays. Despite the success of drilling-in under pressure with rotary, present practice is to run the blank oil string through the pay, cement the string to the surface, and gun perforate opposite the particular pay streaks which it is desired to produce and thus to secure a control over the advance of edge water and injected gas. It is thought that selective acidizing of the limestone pays through the gun perforations reopens those pays which are mudded. A limestone-base drilling mud is being experimented with in the hope that mudded sandstone pays may also be reopened with acid.

The most important drilling event at Bahrein, since the initial discovery, occurred in October, 1937, when well No. 52 encountered the so-called "fourth pay" at 4,150 ft. This pay has now been partially tested by four wells and appears to consist of four separate zones, the porosity and permeability occurring in limestone which is interbedded with anhydrite. Each zone is capped with gas which carries 250 bbl. of white 62 deg. API oil per 10,000,000 cu. ft. of gas. At least two of the zones contain dark 33 deg. API oil between the gas and water. The extent and potentialities of these oil zones are not yet known but it is believed likely that the reserves may be considerable. The first well properly to test the section, No. 58, was recently completed at 4,843 ft. and tested 1,102 bbl. of oil and 679 MCF of gas daily against 720 lbs. back pressure from gun perforations 4,465 to 4,475 ft. Present plans are to keep two or three rotary rigs drilling to the fourth pay. The completion method, at least on the first few wells, will be to cement aluminum liner through the entire section and gun perforate opposite the dark oil pays indicated by formation tests or electrical log surveys. The casing program will be 21½, 16, 11¾, 8⅝, and 6⅝ in. casing, and 4¾ in. liner in these 4,500-ft. wells. It is of interest to note that this same Bahrein "fourth pay" recently was found to be productive on Damman dome in eastern Arabia.

The cumulative production of the field was 13,989,057 bbl., from the main pay, to January 1, 1938. This oil was produced on a rather irregular production program while drilling and refinery construction work was under way. Production is gathered through common flow lines into five degassing stations to avoid duplication of facilities and evaporation losses, and individual well production is periodically metered through a portable orifice meter. The field is produced at only a fraction of its potential

under thorough engineering supervision. The pressure-production characteristics of each well are obtained; complete reservoir pressure surveys are made periodically; all gas production is metered; the source of edge water is determined by "water witch" surveys; and pressure-volume-temperature studies are made of the reservoir crude. Nearly all wells have been acidized to improve flowing characteristics and the resultant average increase in potential is over 200 percent.

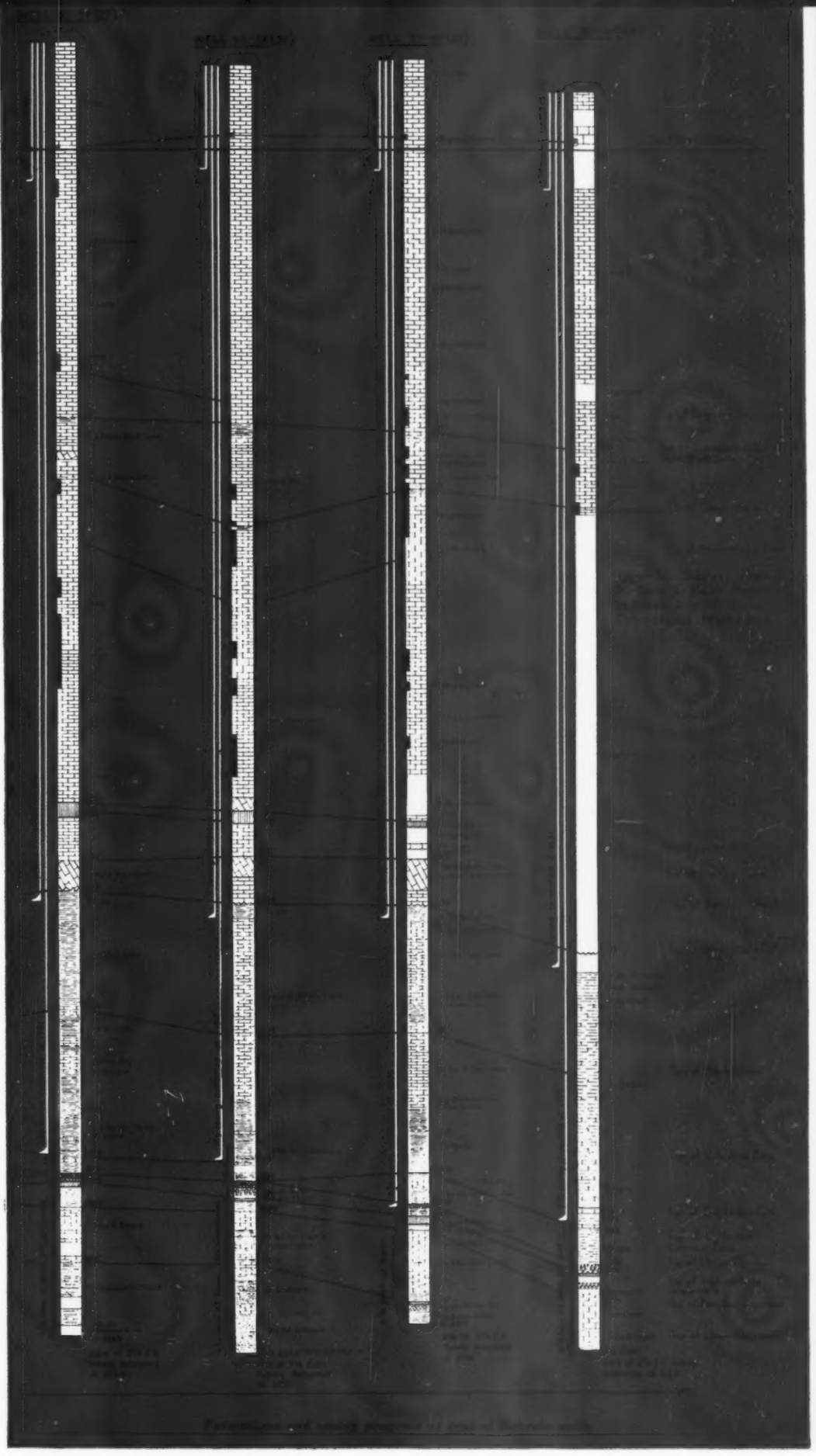
A pressure maintenance experiment was begun in April, 1938. High pressure gas from the fourth pay is being injected into the crest of the main pay through well No. 7. The volume injected has ranged from 3,000,000 to 9,000,000 cu. ft. daily, which is considerably less than would be necessary to replace entirely the 22,000 bbl. of oil now being produced. The injection of this gas has caused a marked reduction in the rate of reservoir pressure loss. It is believed that this crestal gas injection experiment is the first to be attempted on a large limestone reservoir.

An oil camp equipped with every modern convenience has been completed on Bahrein Island. The camp consists of permanent air-cooled living quarters for 105 families and about 200 single employees, together with several temporary buildings, providing sufficient accommodations for all British and American personnel and their families, which now include 75 women and 40 children. The older type of houses were built of gutch with wide verandas. These houses were not originally designed for air cooling but now include this feature. The newer type of houses were especially designed for air cooling.

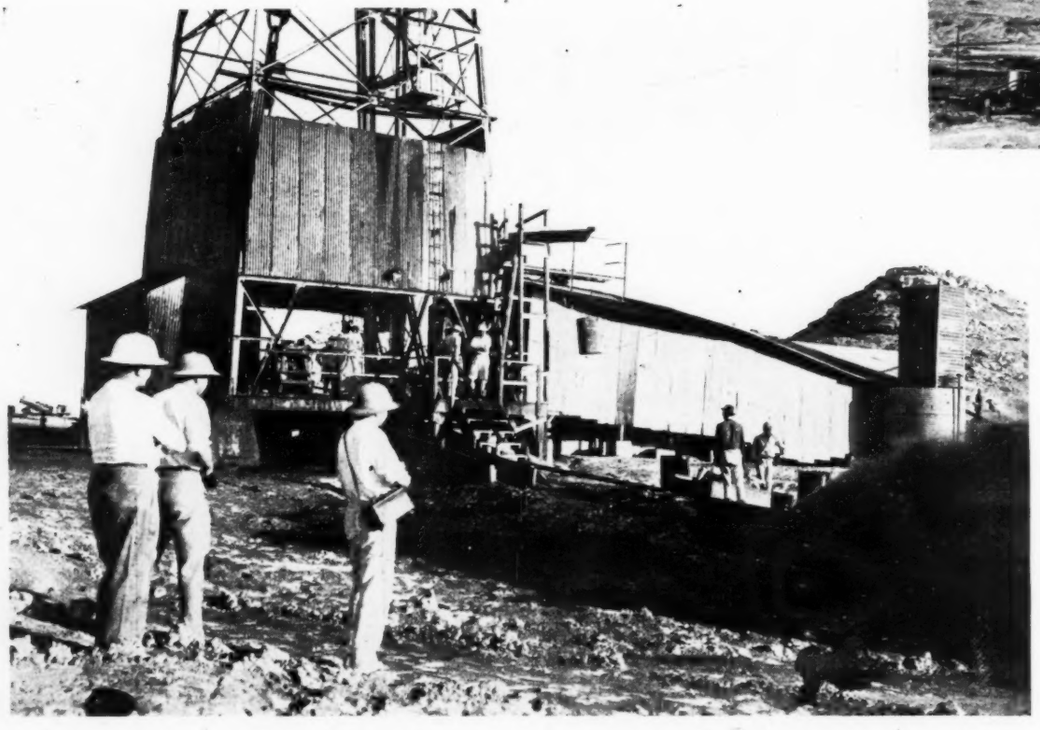
Facilities for the welfare and recreation of the employees include a company maintained club house, commissary, boarding house, air-cooled theater which includes two schoolrooms, air-cooled hospital, a swimming pool with complete purifying equipment, tennis, volley ball and squash courts, golf course and other sports accommodations such as soccer, cricket, and boating.

The producing, refining, and maintenance operations are supervised by specially trained personnel, of whom 250 are from the United Kingdom and 100 from the United States. In addition to these, the company employs more than 2,000 Bahreinis, 450 British Indians, and a total of 550 Iraqis, Iranians, and others.

The Bahrein native workmen are being continually trained in the Bahrein Government trade schools and in the company shops to fit into more responsible work. Many of these natives have shown remarkable ability in learning the English language, and are becoming familiar with the strange mechanical equipment of the oil industry.



Sands of
SAUDI ARABIA
Promise Rich Oil Flow



Above is the California Arabian Standard Oil Company's Damman Dome Well No. 1 which, with the well shown on the left, helped to establish the existence of a large pool in Eastern Saudi Arabia. To the right is shown an air view of the Damman camp and the Damman well. The hills are typical of this part of Arabia along the Persian Gulf. The inset on the right shows the method of taking oblique photos from an aeroplane for aerial exploration of the vast area in Eastern Arabia. Below is a scene typical of the east taken at the company's geological headquarters at Jubial. The camels in the foreground belong to the geological caravan.

In July 1933 the California Arabian Standard Oil Company, subsidiary of the Standard Oil Company of California, obtained from His Majesty Abdul Aziz ibn Abdur Rahman ibn Faisal al Sá ud, a concession "to explore and search for and drill and extract and treat and manufacture and transfer and export" all manner of petroleum, asphalt, oil and other carbonaceous material in an area extending along the eastern side of Saudi Arabia to a distance of approximately 150 miles from the coast. The concession was to run for a period of sixty years, but the company retained the right to withdraw at any time on thirty days written notice. In the event that oil was found in commercial quantities the company was to pay a royalty on its production, to establish a refinery capable of supplying the domestic needs of the country and to turn over to the government annually specified quantities of gasoline and kerosene.

At that time Saudi Arabia was practically an unknown land geologically and in fact few westerners had penetrated the interior of the country. Some few geologists had made superficial observations along the eastern coast but no systematic survey had been carried on. The chief reason for believing that oil might be found within the area was its propinquity to Bahrein where preliminary tests had shown its existence.

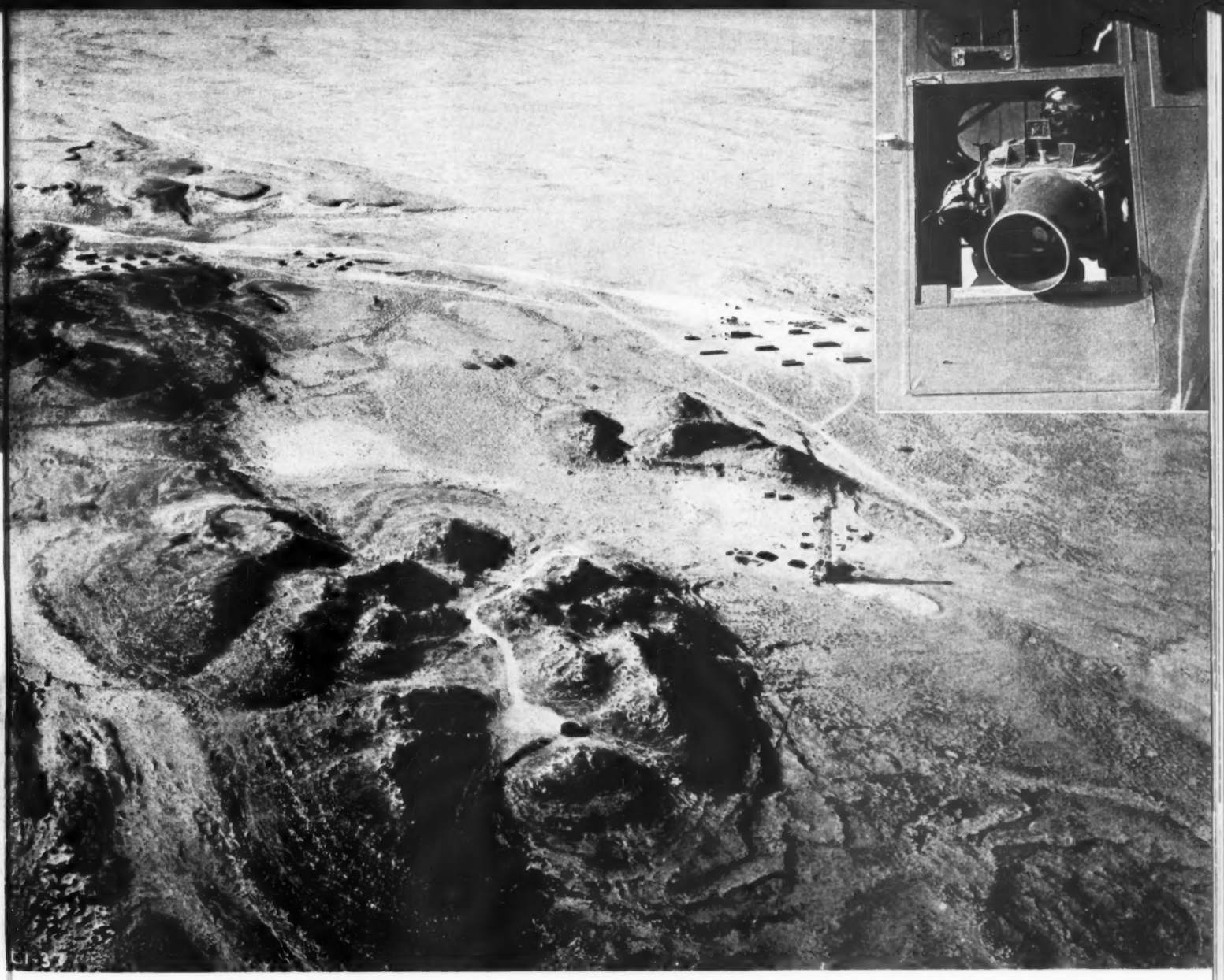
Following the conclusion of the agreement covering the concession and as soon as the necessary provision of equipment could be made a party of geologists was organized and a headquarters camp was established at Jubail. The work of survey then began in earnest, first by aerial photography and then by accepted geological methods. In 1935 test drilling was begun and an operating camp was established six miles inland from Al Khabar and sixty miles south from Jubail.

The first wells drilled were located on the Damman dome, a site selected because of its structural resemblance to Jebel Dukhan, some forty-five miles distant, where the first findings in Bahrein were located. The initial well was a dry hole but the second, Damman No. 2, came in with an encouraging flow of oil of 53 deg. gravity from a depth of 2,152 ft. Ten wells were put down in this area with some production in each case but without sufficient regular flow to prove the existence of a commercial field.

The early wells were drilled to depths of 2,000 to 3,000 ft. but in the case of Damman No. 7, again profiting by experience at Bahrein, the course of the drill was continued downward and in March, 1938, at 4,700 ft., a large flow of high gravity oil was encountered. As a result of this development two of the wells previously drilled are being deepened to the same horizon as that tapped by Damman No. 7 in the belief that worthwhile production may result.

While the main drilling activities of the company have been centered about Damman Dome a test well was drilled on the El 'Alat structure, some 22 miles to the northwest. Work on this well was suspended in June 1937, but as a consequence of the recent discovery at Damman it may be carried to deeper horizons later on.

Meanwhile geophysical surveys have



been conducted in new areas and by this means, in conjunction with ordinary surface geology, several promising structures have been located. On one of these drilling is to begin shortly.

Owing to the physical characteristics of the country, the absence of roads and ordinary transportation facilities and the necessity of bringing in food and water for the exploring parties, survey work in Saudi Arabia presents many difficulties. Much of the interior is a sandy waste, almost without vegetation, its flatness relieved only by sand dunes and depressions that mark the sites of ancient watercourses from which the water itself long since has disappeared. Eastern Saudi Arabia is essentially a great plain, sloping very gradually from the heights in the central and western part of the country to the sea. Most of the exploratory work has been in the northern part of the concession, from Damman Dome northward. It must be remembered that the total area of the concession is somewhat larger than that of California and that many years will be required to explore the whole of it.

The drilling that has been done to date has demonstrated the presence of oil of a high quality in Saudi Arabia. The surveys have shown the existence of vast structures which, according to the law of probabilities should contain oil. Those who are most familiar with the evidence thus far uncovered are convinced that Saudi Arabia is destined to become an oil producing area of major importance and one in which large fields will have the advantage of locations relatively close to water transportation.

During the past year Damman camp has begun to take on the appearance of a permanent oil town. A large amount of work has been done to insure the comfort of employees. A modern sanitary system has been installed, ten cottages for families have been built and four large bunk houses for single men, all of them air-conditioned.

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Users of the Guiberson HIGH PRESSURE Rotary Pipe Line Pump get all of the advantages from making a direct connection to the power unit . . . Natural Gas, Diesel, or Electric. This direct connection feature is just aonther demonstration of the engineering results that 8 years of research and experimental field work have achieved in eliminating waste in the pumping of crude oil.

High efficiencies at constant high operating pressures is another advantage users are assured. And regardless of the pressure or volume of crude being handled, the discharge is at all times free from pulsation. This is made possible by the positive displacement action within the gears. Especially hardened steel is used in the gears to withstand any abrasive action of particles in the crude. This, together with the close fit of gears assure not only high efficiencies at unusually high pressures but also long operating life.

Flexibility is obtained through the acceleration of power or through the gear advantage by use of a clutch. The unit is given a wide field of usefulness and may be adapted to many different pumping jobs by mounting on a truck or trailer —see photo on the opposite page. Often, power for the pump can be furnished by the truck.

Units are available in sizes ranging from 10 barrels per hour up, and pumps which will produce 36,000 barrels of crude per day are in process of manufacture.

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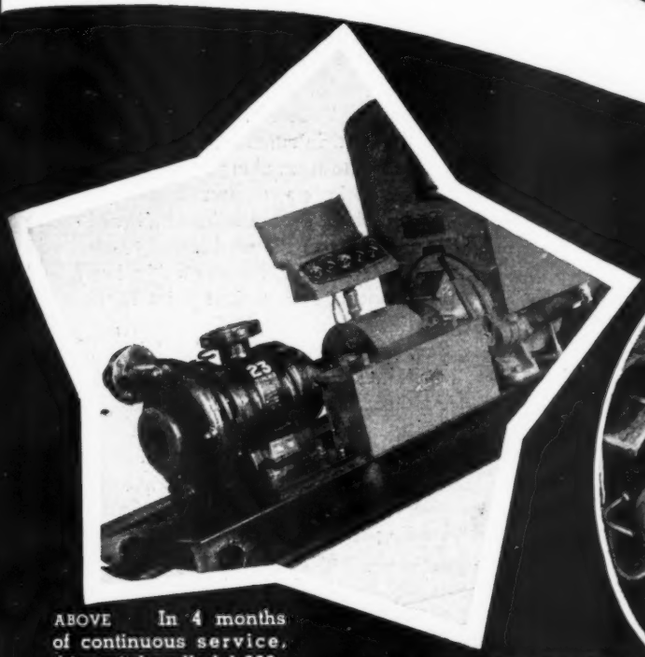
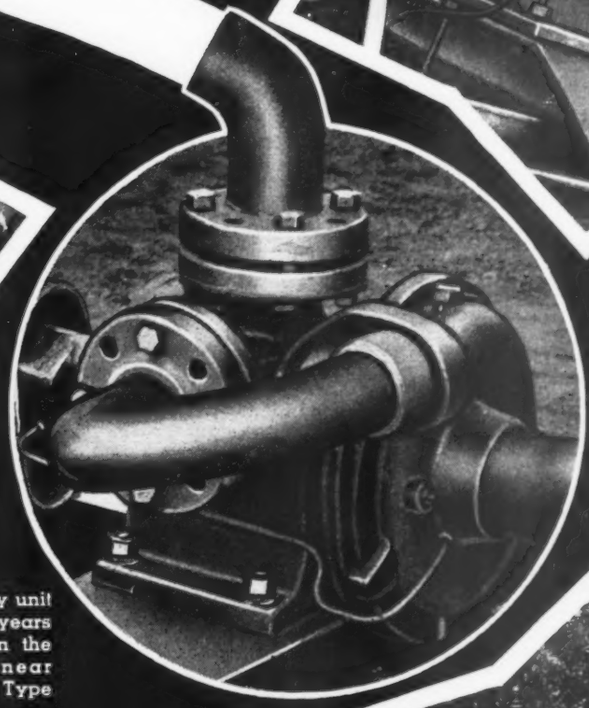
ABOVE Thompson Field, South Texas, this unit has been in continuous service for 3 years and has handled more than 2,500,000 barrels of crude. At 860 r.p.m. the operating pressure is 640 pounds; the capacity 185 barrels per hour. This unit is Type 6FB5.



ABOVE In 4 months of continuous service, this unit handled 1,000,000 barrels of crude in the Rio Bravo Field, California. It operates at 1,400 r.p.m. at 300 pounds pressure and at a capacity of 310 bbls. per hour. Type 6FB5.



RIGHT A stationary unit which has given 2 years continuous service in the Monument Area near Eunice, New Mexico. Type 4FB8.

LEFT BELOW This stationary unit, Type 4FB8, is giving satisfactory service in the East Texas Field, operating at 1,600 r.p.m. and at 600 pounds operating pressure handles 167 barrels per hour.

RIGHT In service in North Central Texas, this trailer mounted unit, Type 3FB8, illustrates the advantages of an easily portable high pressure pump. Its capacity is 65 barrels per hour at 1,600 r.p.m. with an operating pressure of 450 lbs.

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300,000 bbl. Approximate Throughput, 100,000 bbl. Cracking Capacity, 65,000 kw. Power Output, More Water Pumping Capacity Than Is Found in the City of London, a Description of This Remarkable Plant Is Composed of Superlatives.

HIGH in the mountains of Armenia there rise the twin great rivers of classical and biblical history, the Euphrates and the Tigris. Close together at their sources, the two rivers follow widely different courses till at last they meet in the lower Mesopotamian desert, to form a single stream, the Shatt-al-Arab or Arab River, which, after flowing for 90 miles in a south-easterly direction, empties itself into the Persian Gulf.

A third, but smaller, river, the Karun, not without historical importance, has its source in the Bakhtiari Mountains in southwestern Iran. After emerging from the mountains near Shushtar, it flows through 150 miles of desert to join the Shatt-al-Arab at Khorramshahr (formerly Mohammerah) 30 miles from the Gulf.

Not all the water of the Karum, however, enters the sea by way of the Shatt-al-Arab, for several sluggish channels, some of them at times losing their identity in marshland, leave the main stream as it crosses the desert plain and eventually reach the sea by courses roughly parallel to that of the Shatt-al-Arab.

Of these subsidiary mouths of the Karum the largest and nearest to the Shatt is the Bahmashir, and the tract of desert between the Bahmashir and the Shatt-al-Arab, 30 miles long and varying in width from two to 10 miles, is the island of Abadan.

The great Abadan refinery of the Anglo-Iranian Oil Co. seen from about four miles across the desert.

Until 1909, Abadan Island was a patch of alluvial desert, flooded in winter, baked hard in summer, edged by a narrow belt of date trees along the river banks and differing in no respect from the other thousands of square miles of alluvial desert in that part of the world.

But it happened that on Abadan Island was the most convenient point for bringing to tide-water the pipeline from the newly proved oilfield of Masjid-i-Sulaiman, whose exploitation was being undertaken by the Anglo-Iranian (then Anglo-Persian) Oil Company under its concession from the Imperial Iranian Government.

The site chosen for what was to grow into one of the world's greatest refineries and loading terminals was on the Shatt-al-Arab shore at the narrowest part of Abadan Island, about eight miles from its northern extremity at Khorramshahr, and about 25 miles from the sea.

The first shipload of crude oil left Abadan in May 1912, and the first battery of stills was started in the early months of the following year.

The extent to which the capacity of the refinery has grown during the intervening years may be gathered from the accompanying figures of petroleum production in Iran, the very great bulk of which is refined at Abadan.

Iranian Crude Production

Year	Long Tons
1913	80,800
1918	897,402
1923	2,959,028
1928	5,357,800
1933	7,086,706
1937	10,167,795

However, this article is not intended as a history of the district of Abadan. Its purpose is to present to the reader an account of Abadan refinery as it stands at the present day, and of the processes carried on in it.

At the present time, Abadan receives its crude from the Masjid-i-Sulaiman and Haft Kel fields through the pipeline system shown on the map. The two crudes, which are not very dissimilar in composition, are stabilized at the fields and are delivered to Abadan containing no more methane and ethane than can be used as fuel in the refinery.

Although a reserve stock of crude is kept in tankage at Abadan, during normal

operation the stills are fed from a ring main into which boosting pumps deliver at a pressure of 40 lbs. per sq. inch.

The main characteristics of the crude are as follows:

On straight distillation, it yields 33.5 percent at 200 deg. C., 44.5 percent at 250 deg. C., 56.0 percent at 300 deg. C., leaving a residue of comparatively low sulphur content.

The gas oil is of high cetane number, and forms a light Diesel fuel. The kerosene contains about 20 percent of aromatics, while the spirit fractions, except for the lowest-boiling portions, are of too low an octane value to satisfy present-day No. 1 motor spirit specifications without reforming.

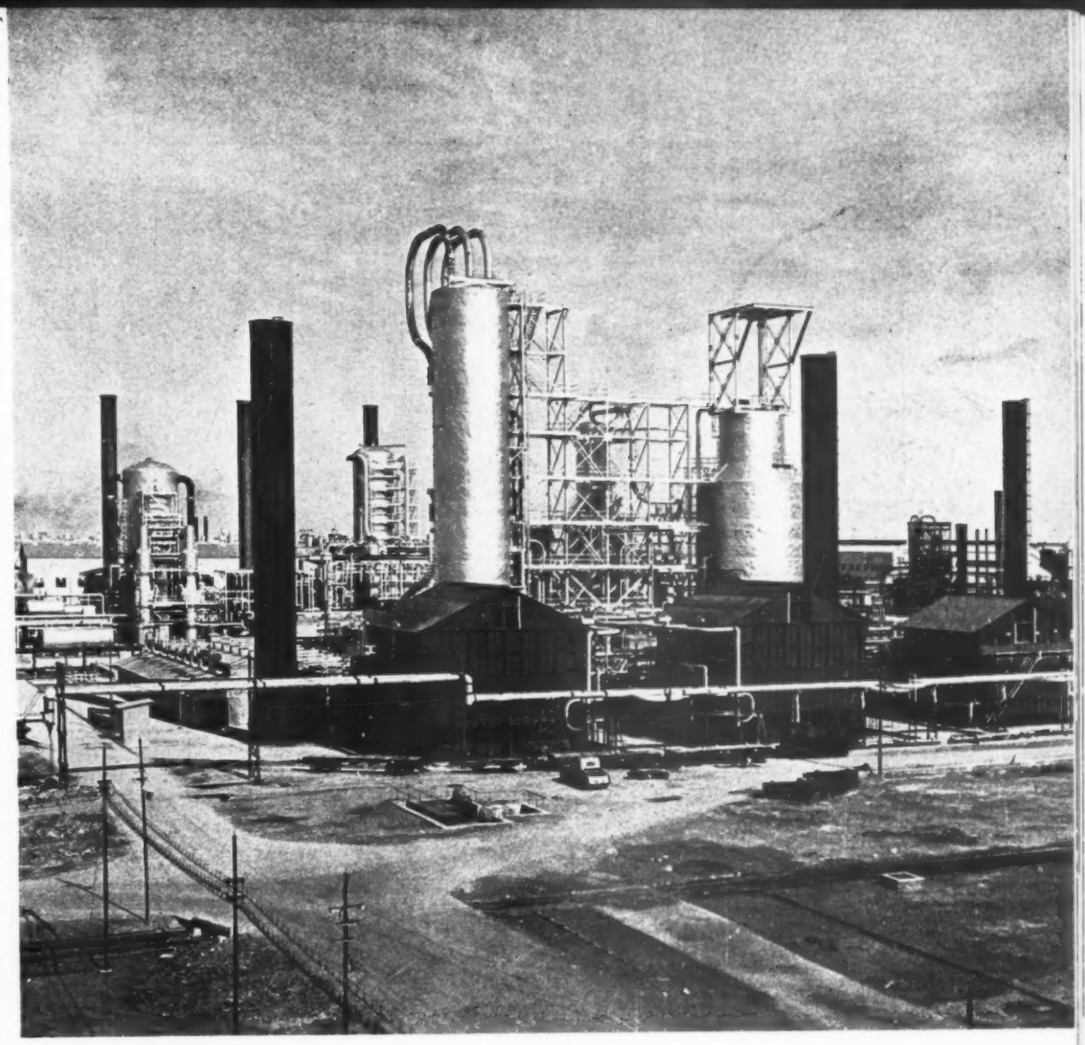
These facts are responsible for the refining scheme operated in Abadan. The crude oil is distilled in three stages. In the first stage, it is preheated to 350 deg. F. and injected into a fractionating tower working at 50 lbs. per sq. inch, the overhead from which, representing eight to 10 percent of of the crude, has an end point of 100 deg. C., and, after stabilization and sweetening, is ready for incorporation in motor spirit. The topped crude from the 50-lb. tower is then submitted to ordinary pipe heater and tower distillation at atmospheric pressure.

The overhead from the column, a spirit of about 140 deg. C. end point, is the highest-boiling straight-run fraction used in motor spirit blends, and the first side stream, amounting to about 25 percent of the crude, is the charging stock for the reforming units that produce the bulk of the motor spirit output.

Kerosene and gas oil are obtained as lower tray cuts, and the residue from the atmospheric stage (45 percent on the crude) is the main constituent of Abadan's furnace oil output.

Only part of the residue from the atmospheric columns goes on to the third, or vacuum stage, of the distillation process, which produces a further quantity of straight-run gas oil, and a heavy cut containing the bulk of the wax, leaving as residue a pitch amounting to about 12 percent on crude. The waxy cut is used as cracking stock, and the greater part of the pitch is incorporated in the furnace oil output of the refinery, together with the cracked gas oil and cracked heavy residue produced from the waxy cut and from naphtha reforming. Since the cracked gas oil and residue are wax-free and the extra asphalt in the pitch is an effective inhibitor of wax deposition, the final furnace oil blend has a pour-point much lower than that of the corresponding straight residue fuel oil.

There are at present six modern crude distillation units operating on these lines.



One of the large three-stage distillation units capable of handling 75,000 bbl. of crude per day at the Abadan refinery in Iran.

Three of them, with a combined capacity of 80,000 bbl. per day, provide only for the high pressure and atmospheric stages, but a separate vacuum stage unit is provided for handling 24,000 bbl. of the atmospheric residue they produce.

Of the three three-stage units, one provides for the complete three-stage distillation of 28,000 bbl. per day of crude oil; the other two, of almost identical design, are believed to be the largest distillation units in existence. Each has a capacity of 75,000 bbl. per day for crude oil, but the vacuum stages can each handle only about 15,000 bbl. per day, i.e., rather less than half of the residue from the atmospheric stage.

These two units are remarkable not only for their size, but also for ease of control. All temperatures, pressures and rates of flow pertinent to the operation of the plant are indicated and recorded on a central instrument board, from which all important valves can be operated by distant control gear.

Much of the equipment is fully automatic, e.g., the firing of the furnaces is regulated automatically to maintain constant transfer line temperature.

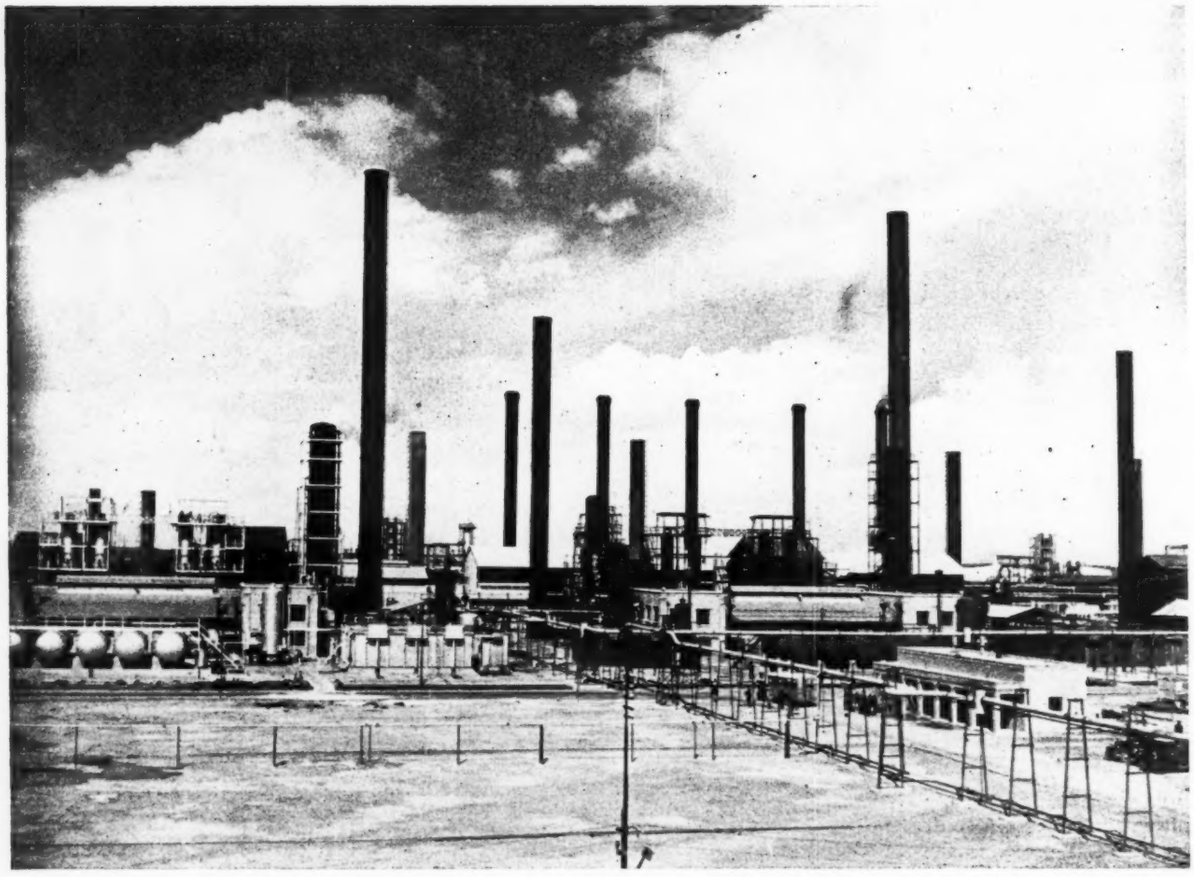
In addition to the plant used for the three-stage distillation process described above, there are in use a number of shell-still and pipe-still units, with a total capacity of 60,000 bbl. per day, working at atmospheric pressure only and incapable of condensing the lightest fractions recovered in the pressure stage of the modern plant.

For this reason crude, before being fed to these units, is stripped of its lightest components in a stablizing plant; also, the vapors remaining uncondensed after passing through the condensers of the older distilling units are piped to a central compressor station where, together with the gases from the stabilizing plant, they are compressed and condensed at 50 lbs. per sq. inch. The 50-lb. condensate thus produced is essentially of the same composition as the first stage overhead of the modern distilling equipment, with which it is combined for all subsequent treatment.

CRACKING

Cracking at Abadan dates from 1931. There is now a total installed capacity of approximately 100,000 bbl. per day, and the operation carried out is chiefly reforming of naphtha.

Naphtha reforming units are repre-



A section of the cracking equipment at the Abadan refinery.

sentative of the most modern type of plant employed for this purpose. For example, the last equipment to be installed consisted of four 12,000-bbl. units arranged as two pairs, each pair around a central control house.

These units consist essentially of a double radiant section furnace, together with integral stabilization and fuel flashing equipment. Particular care was exercised in deciding on the design of the furnace in order to ensure that a maximum flexibility for high octane number production from naphthas of varying end points was achieved.

The units operate under peak conditions of 800 lb/sq. in. and 1025 deg. F. on the transfer line, and high yields of 72 octane number pressure distillate are obtained.

Apart from the major operation of naphtha reforming, considerable cracking plant capacity is employed on the cracking of heavy distillate obtained from the vacuum distillation of 45 percent residue. This heavy oil cracking is noteworthy in that no straight-run gas oil is available for the dilution of this heavy wax-bearing distillate.

The object of the operation is the conversion of the wax into liquid products, and to achieve the best results several major modifications had to be made in the design of the units, which were originally standard type viscosity-breaking units.

The wax distillate cracking operation, as it is described, is now directed solely to the production of the maximum quantity of distillate fuel blending stock.

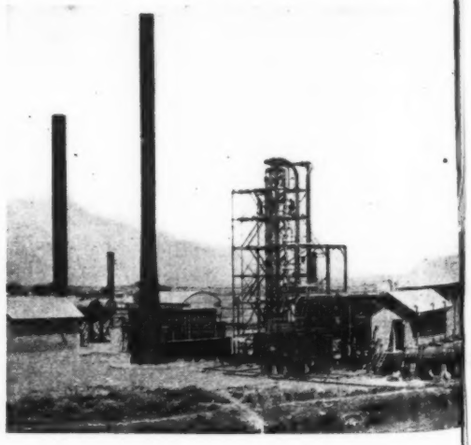
ACID TREATING

An important factor in all distillate cracking schemes is the treatment of the spirit produced. In Abadan the pressure distillate first receives an acid treatment, followed by redistillation and a final hypochlorite wash. Both acid and hypochlorite treatment are carried out in equipment of the well-known Holley-Mott type in which circulation of the liquids being contacted is maintained by the differences in density between the oil reagent mixture produced by stirring in an agitating vessel, and the separate liquids in a separator vessel, the two vessels being cross-connected by short open pipes at the bottom and approximately half way up.

A complete acid treating unit consists of eight pairs of agitator and separator vessels, of which five are devoted to countercurrent acid washing, the sixth gives a neutralizing water wash, and the seventh and eighth a final soda wash. Using plant of this type, remarkable efficiency is obtained, particularly with acid treatment. The consumption of acid in Abadan P.D. refining is less than one fifth percent, which means that the actual reagent in contact with the distillate is, in effect, acid tar. Polymerization loss is very low.

For the redistillation of pressure distillate, five units are provided, each having a daily capacity of 14,000 bbl. of P.D. which is taken down to a five percent residue. In three of the units a pipestill and column of normal design are used to take the P.D. down to a 20 percent residue,

Anglo-Iranian's refinery at Kermanshah showing the pipe still and fractionating column.



which is further reduced in two steam-heated vacuum stages. In the last stage, distillation is assisted by the injection of open steam at the base of the column.

The two newest P.D. redistillation units work on the same three-stage plan, but in these all three stages are steam-heated, the fired pipestill being eliminated.

KEROSENE

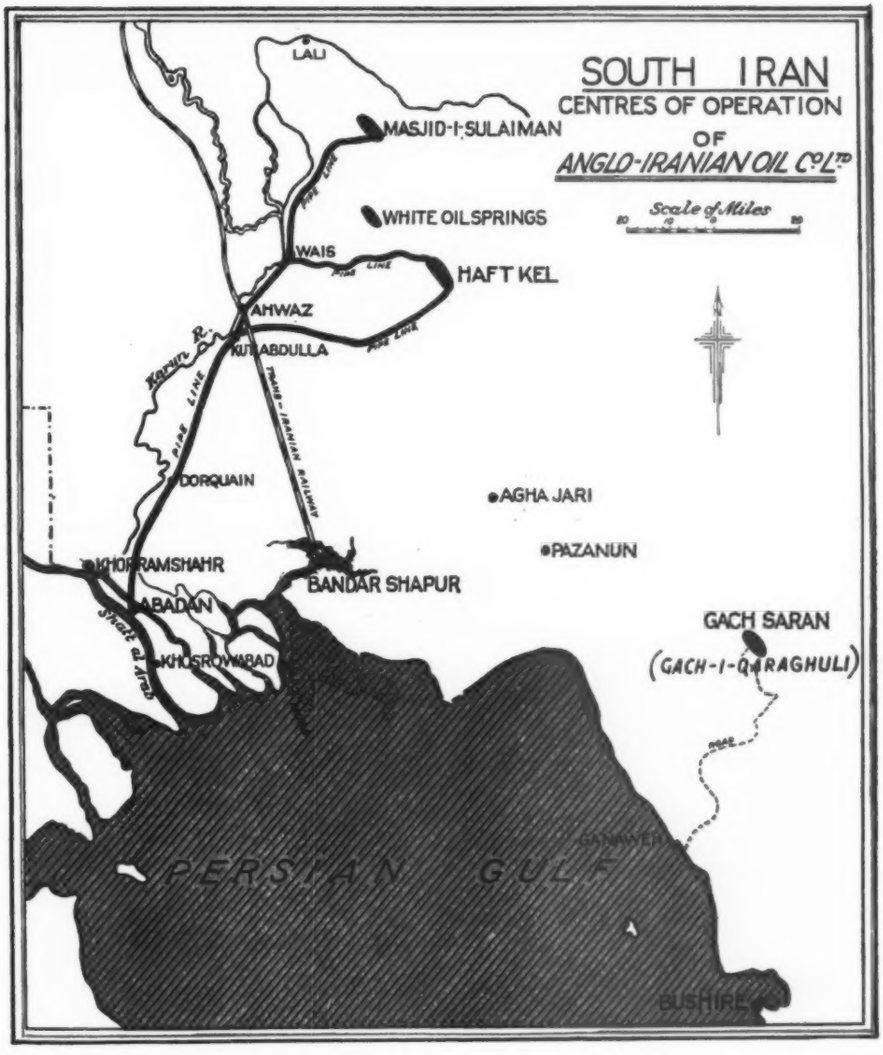
We now turn to the treatment of those products of crude oil distillation that are not destined for use as cracking stock. Of these, the straight-run gasoline requires only a simple hypochlorite treatment to fit it for incorporation in motor spirit blends, while gas oil for sale unblended with residual oil receives a light soda wash. The kerosene, however, needs more drastic treatment. As mentioned at the beginning of this article, the kerosene fraction in Iranian crude contains some 20 percent of aromatics. Since aromatics impair the clean-burning qualities of a kerosene, it is desirable to remove them from this product and to incorporate them in the motor spirit, on which they confer valuable anti-knock properties. The transfer is effected by extraction with liquid sulphur dioxide, which at low temperatures (about 14 deg. F.) has a powerful solvent action on aromatics while remaining inert to most aliphatic hydrocarbons.

The kerosene produced in Abadan is therefore subjected to SO_2 extraction in two plants having a combined capacity of 20,000 bbl. of kerosene per day. In these plants the kerosene and SO_2, after cooling to the required temperature, are contacted in counter-current fashion in packed towers, The SO_2, which now contains in solution the aromatics extracted from the kerosene and the undissolved part of the kerosene, which itself has dissolved some SO_2, are then redistilled for the recovery of SO_2, which is returned to the process, leaving behind an aromatic-free refined kerosene and an aromatic extract. About 57 percent of the extract boils within the motor spirit range and is distilled off in a battery of stills reserved for this purpose, leaving a residue which distills within the gas oil range, and is therefore transferred to that product.

An interesting point about the aromatic extract from Iranian kerosene is that it is not only high in anti-knock value, but is also an effective inhibitor of gum formation in cracked spirit.

GAS UTILIZATION

For many years, the Anglo-Iranian Oil Company has been working on the problem of utilizing the gas contained in crude oil and that produced in cracking reactions. As in other refineries, these were at one time regarded as a total loss except in so far as they could be used locally to replace solid or liquid fuel.



Map of South Iran showing fields, pipelines and refineries of the Anglo-Iranian. Note the newly developed field Gach Saran.

Gas recovery technique has, however, advanced to the point where the complete conversion into saleable products of all the light hydrocarbons, except methane and ethane, is in sight, and of these the quantities available in Abadan can be utilized to replace liquid fuels that would otherwise have to be used for refinery purposes.

The following is a brief outline of the gas conversion processes that have attained the commercial plant stage in Abadan. Several other processes are in the pilot plant stage.

The gas (by which is meant all hydrocarbons that cannot be included in the motor spirit make without unduly raising its vapor pressure) available in Abadan is of three kinds.

The first, or straight-run gas, is the overhead from the stabilization of the primary (50-lb. stage) distillate from crude oil distillation, and consists of saturated hydrocarbons only.

The second kind of gas comes from the high pressure P.D. separators on the cracking plants, and consists mainly of methane and ethane, with some hydrogen.

The third gas is the overhead from the pressure distillate stabilizers and contains not only saturated hydrocarbons from ethane to butane, but also ethylene, propylene, butylenes and some hydrogen.

The straight-run gas contains ethane, propane, butanes and isopentane, and the first operation carried out on it is the separation of the isopentane by close fractionation. Isopentane is a particularly valuable product since it has a high octane number and its vapor pressure makes it suitable for blending with less volatile products, such as iso-octane, to form a well balanced aviation fuel. A fractionating unit specially designed for large scale isopentane production is now in course of erection.

The remainder of the gas, after removal of the isopentane, is refractionated into

A general view of the Abadan refinery from the west giving some idea of the extent of the plant.

ethane, which is used as works fuel, and propane-butane mixture. A portion of this mixture undergoes a further close fractionation to produce nearly pure butane for use as bottled gas, and another portion goes to a high temperature pyrolysis unit producing 5,000 bbl. per day of aromatic-rich near-benzol.

The high-pressure cracking plant gas is nearly all usefully consumed as refinery fuel; but a portion of it is now used as a source of hydrogen for the recently erected hydrogenation plants discussed below. The stabilizer overhead gas, however, is by virtue of its high unsaturated content a most valuable raw material for polymerization processes. It is first fractionated to separate from the lighter hydrocarbons the butanes and butylenes, and the latter are then agitated with cold 55 percent sulphuric acid, which reacts selectively with the isobutylene forming tertiary butyl alcohol. This goes into solution in the acid, and when the solution is heated to 180 deg. F. decomposes to form the polymer di-isobutylene.

Di-isobutylene is itself an exceedingly valuable anti-knock component for motor spirits, but can be converted by hydrogenation into the still more valuable iso-octane, and a plant for carrying out this operation is now being commissioned in Abadan. Lack of space precludes any description of the plant, which includes an elaborate equipment for the production of pure hydrogen from cracking plant separator gas by a series of catalytic reactions.

The butane and n-butylene, which pass through the acid polymerization plant unchanged, are blended back with the lighter portion of the stabilizer gas for treatment in a catalytic polymerization plant, producing a high octane mixed polymer spirit.

The above account of processes and plant in Abadan is, of necessity, very sketchy. It has omitted, for instance, all mention of the preparation of what one may call secondary products, meaning products made only in quantities that are small by comparison with the tonnage of motor spirit, kerosene and fuel oils. Such are: white spirit, road asphalts, vaporizing oils and special aviation spirits. Again, no mention has been made of the extensive chemical manufacturing plant, the importance of which may be exemplified by the facts that all the sulphuric acid used is manufactured in the refinery, and that most of the alkali washing of distillates is carried out with lime water obtained from locally burnt sea-shells.

STORAGE

The storage capacity at Abadan amounts to about 6,000,000 bbl. mostly in the form of 70,000-bbl. tanks. This tankage is located in two large tank farms, one of which is between the refinery and the Bahmashir River and is reserved for fuel oils, gas oils and reserve crude; the other, for kerosene and aviation and motor spirits, is at Bawarda, on the Shatt-al-Arab, three miles below Abadan. Nearly all the Bawarda tanks are equipped with floating roofs.

Ten oil loading jetties for deep-sea tankers have been built along the Abadan-Bawarda foreshore, in addition to a quay, 1,350 ft. long, for discharging refinery material from cargo vessels and for loading pitch in barrels. There are also several smaller jetties for loading barges with oil for shipment to points on the Euphrates-Tigris-Karun river system, both in bulk and packed in tins (Abadan has a tin factory with a daily capacity of 20,000 eighteen litre tins).

The marine equipment also includes a well-equipped workshop for ship repairs and a floating dock enabling complete overhauls and surveys to be carried out on the small craft employed on the rivers and the Persian Gulf traffic.

The tonnage of oil now exported from Abadan has almost reached the maximum permitted by the number of loading jetties that can be accommodated on the available foreshore, and also by certain geographical characteristics of the river limiting the number of ocean-going vessels that can be handled up to Abadan and the ports higher up on any one tide. Further expansion will therefore involve a new loading terminal.

POWER

It is not possible to mention here all the various technical services without which the refining plant in Abadan could not function, but space must be found for some account of the three fundamental power services—water, steam, and electricity.

All the water used for process purposes (mainly as condenser and cooler water) is pumped from the Shatt-al-Arab at the upstream end of the refinery foreshore and eventually returns through a network of underground piping and large concrete culverts discharging through oil separating ponds into an effluent channel that rejoins the river half a mile lower down. The water-pumping station is of particular interest.

The pumping sets, five in number, are the most powerful yet constructed of their type. All are single stage geared turbine driven centrifugals and deliver against a pressure of 65 lb. per sq. inch. Three of them, each having a capacity of 2,000,000 imperial gallons per hour, have twin impellers with the suction branches at opposite ends of the casing; the other two sets (4,000,000 gallons per hour each) consist each of two separate single impeller pumps mounted in tandem.

The total capacity of the five pumping sets, 14,000,000 gallons per hour, is greater

than the average rate at which water is distributed by the Metropolitan Water Board to London and the surrounding areas.

The five pumping sets are mounted 12 ft. below ground level so as to ensure flooded suctions at all states of the tide. Since the subsoil is saturated with water, the construction of the foundations, which are in effect a floating box of reinforced concrete, was a matter of considerable difficulty.

Four vertical tube boilers, each designed for 45,000 lbs. per hour of steam at 220 lbs. per sq. inch, provide the power for the pumping sets.

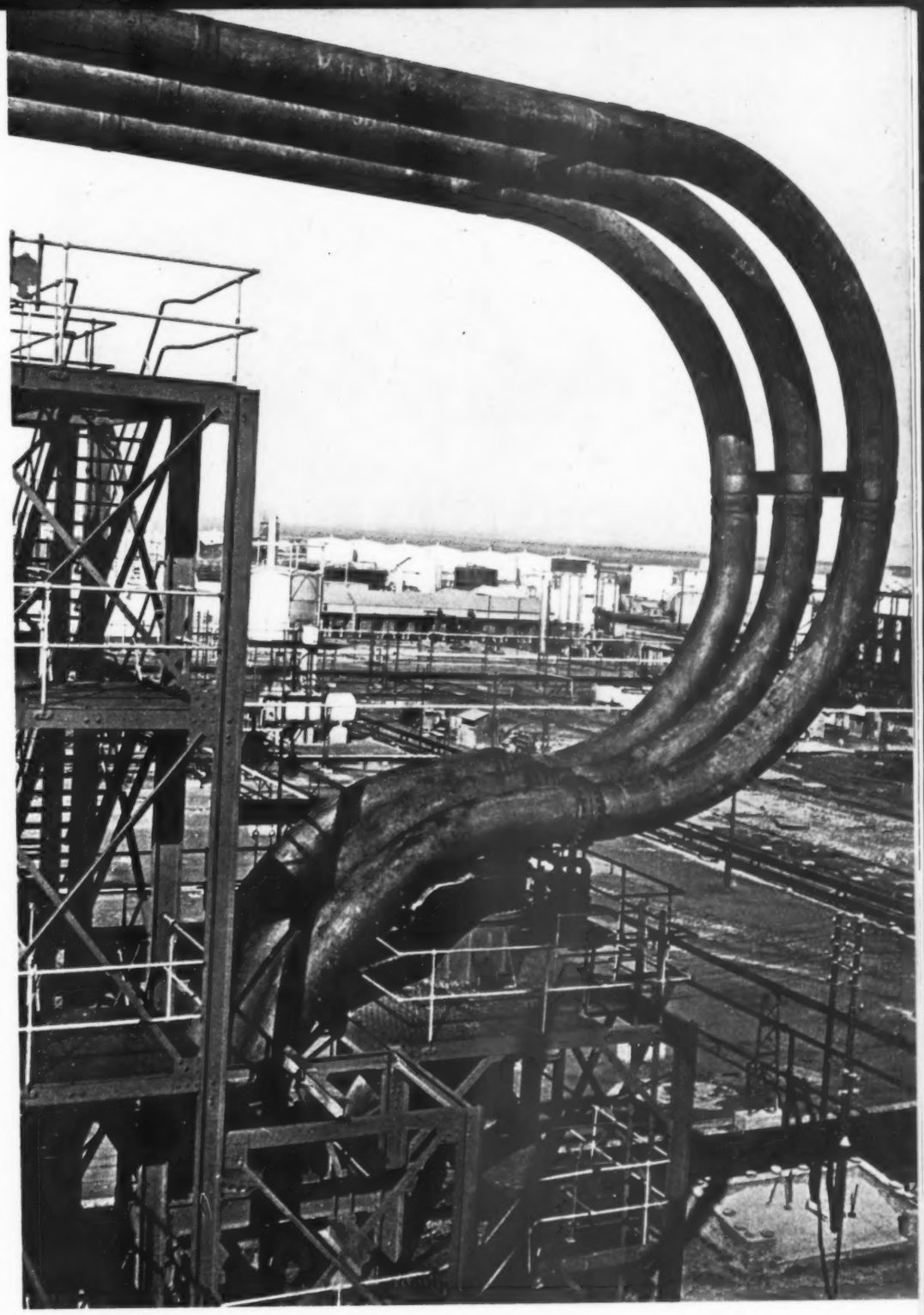
Both steam and electrical power are used in almost every unit of the refinery. Electric motors drive most of the pumps and other machinery, all lighting is, of course, electric, and an electric power supply is required for the numerous control instruments, which, while not large power consumers, are essential for process operations.

As for steam, large quantities are required for process purposes, and it has been found advisable to use steam drive for numerous pumps, particularly on the cracking units, since the sudden stoppage of an important pump might have extensive and expensive consequences, and an interruption in the steam supply is considered to be, on the whole, a more improbable eventuality than the tripping of a switch.

While for special reasons certain steam-consuming units have their own boiler installations (the main water pumphouse is the most important of these) most of Abadan's steam demands are supplied from two large batteries of water-tube boilers. One of these batteries, in the neighborhood of the cracking plants, supplies process units only. This battery consists of twelve boilers, all supplying steam at 220 lbs. per sq. inch and 500 deg. F. Ten of these are of the vertical straight-tube type and are rated at 45,000 lbs. per hour each. The other two are bent-tube boilers rated at 150,000 lbs. per hour each.

The other large boiler battery performs a dual function and supplies steam not only to process units, but also to the refinery electrical power station. It includes four boilers of 150,000 lbs. per hour capacity, identical with those at the cracking plant battery, and twelve older and smaller boilers, four being of 40,000 lbs. per hour and eight of 25,000 lbs. per hour capacity.

The electric power station itself contains two 6,000 K.V.A. and two 4,000 K.V.A. turbo-alternators, and also two smaller machines which are to be replaced this year by new sets of 22,500 K.V.A. each, making a total installed capacity of 65,000 K.V.A. Power is transmitted at 3,300 volts, 3-phase, 50 cycles, to 22 sub-stations in Abadan and Bawarda, from which it is distributed at the same voltage for large motors and at 440 and 250 volts for small motors and lighting.



Looking through the vapor lines of a vacuum reducing unit at Abadan.

To ensure continuity of supply the feeders to the sub-stations are all arranged on the ring main system, so that every sub-station is fed by two different routes. (The principal steam and water supply mains in the refinery are laid out in a similar manner). There is also an 11,000 volt transmission line supplying the town of Khorramshahr, eight miles away.

From the technical features which have been described in this article, it will be gathered that no effort has been spared to ensure that the great establishment at Abadan fulfils the primary function of a well-conducted refinery in obtaining from every ton of crude oil that it handles the maximum amount of best quality products derivable from the crude.

AFGHANISTAN Prospects Promising for Future

Surrender of Concession by Inland and by Amiranian in Northern Iran Due to Requirement of Early Production and to Opening of Large Competitive Fields—Surveys Afford Encouragement for Further Development.

FOLLOWING negotiations with the governments of Iran and Afghanistan conducted by Frederick G. Clapp, well-known geologist, and Charles C. Hart, former Minister of the United States to Iran, oil exploration and exploiting concessions were granted early in 1937 to Amiranian Oil Company and Inland Exploration Company. A license to construct a pipeline through both countries to tidewater—the probable terminus being Chabbar on the Arabian Sea—was issued to a third company, Iranian Pipe Line Company. The Amiranian company's concession covered a large area in northern and eastern Iran while that of Inland Exploration Company included all of Afghanistan. The three companies were under common ownership, the principal interest being that of Seaboard Oil Company of Delaware.

Immediately following the granting of the concessions geological parties were organized and sent out to both countries and a preliminary survey was begun and continued up to June of this year. In the course of this work a number of very promising structures were located. The most favorable of these were situated in zones extending along the northern and western borders of Afghanistan and in northern Iran to eastward and southeastward of the Caspian Sea. Other sedimentary basins showing good prospects of oil were located in the southeastern part of Iran. So favorable was the outlook considered that a large consignment of drilling machinery and transport equipment was shipped out to Basra for the drilling of test wells.

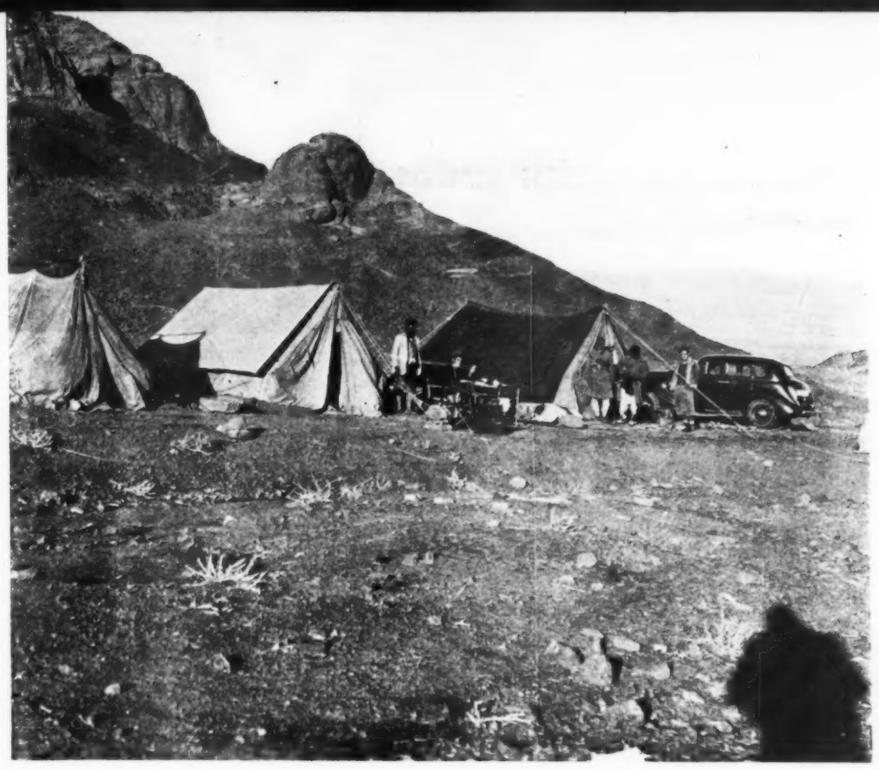
The survey was made under the personal direction of Frederick G. Clapp who has spent much time in the Near East and is thoroughly familiar with the area. He was assisted by his son, E. Gardner Clapp. A large surveying party in southeastern Iran was headed by Lester E. Thompson, assisted by Dr. Hubert G. Schenck, who is Professor of Palaeontology in Stanford University, and Henry Hotchkiss. Dr. Schenck conducted palaeontological researches through the great thicknesses of Lower Tertiary and Upper Cretaceous sediments in this area while Mr. Hotchkiss made detailed surveys of some of the more attractive structures. Headquarters for this part of the work were located at Zahidan in Mekran province. Ernest F. Fox and Bennett F. Buie have been engaged in a special study of favorable areas in Afghanistan. Mr. Clapp, in the course of the past year, has covered practically the whole area of the concessions in almost continuous tours of inspection.

While these geological studies were going on developments by other companies indicated a large increase of Near East production. The location of rich deposits in deeper zones in Bahrein and the indication of similar conditions in eastern Saudi Arabia forecast the probability of great additions of low cost crude to the Near East supply. The finding of high quality crude a Kuwait pointed to another important field while the Anglo-Iranian Oil company has located prolific deposits in southern Iran, within 200 miles of its Abadan refinery. All these areas have the advantage of having water transport available within relatively short distances and of being capable of producing at low cost.

By comparison the exploitation of oil in northern Iran and Afghanistan promised to be an expensive undertaking. Only a part of the distance from the available ports is covered by a rail line and truck transportation would have to be relied upon to move equipment over mountainous and nearly roadless routes to drilling sites. With production established, pipelines a thousand miles or more in length would have to be built across a difficult terrain to move the crude oil to tidewater.

None of these obstacles are insurmountable. Production has been developed in many parts of the globe that are difficult of access and pipelines have been laid across deserts and over mountains. In the very nature of things, however, the investment required by such works adds to costs. With the prospect of active competition from much cheaper production and in view of the present world economic situation, it was decided by the financial interests of the three companies that conditions did not warrant the investment required for immediate development. Accordingly, it was arranged by mutual agreement with the governments concerned that the companies should surrender their concessions. On June 28 a statement was given out at the offices of the companies in New York which said in part:

"During the past year, geologic field parties have been studying these areas and excellent oil possibilities have been in-



On the left is a sandstone outcrop saturated with crude northeast of the Muzuran Pass in Northeast Khorasan, Iran; above, Camp Kunji of the Amiranian Oil Company's geological party in Iran.

dicated. However, because of world economic conditions and particularly those prevailing in the oil industry as related to supplies of petroleum readily available to world markets, the companies have decided to discontinue the work and to surrender the concessions.

"In announcing the termination of this work and the surrender of the concessions, officials paid particular tribute to the courtesy and splendid cooperation extended the companies by the governments of Iran and Afghanistan. Notice of surrender has been given the governments in accordance with the terms of the respective concessions."

Aside from the reasons set forth in this statement it is considered by those familiar with conditions that the terms of the concessions were rather onerous, particularly in light of the changed position as to economic conditions and supplies available in other quarters. The royalty on all oil produced by the Amiranian Oil Company was to be four shillings per ton. The total amount to be paid annually by the company to the government was to be a minimum of £300,000 ($1,500,000) during the five years commencing with the final quarter of the fifth year following the ratification of the concession. After the tenth year the annual payments were to amount to not less than £500,000 ($2,500,000), and not under £600,000 ($3,000,000) after the fourteenth year and until the expiration of the concession.

During the first 25 years of the concession, complete exemption from all taxation was granted to the company, in return for a royalty of 9 d. (18c) on the first 6,000,000 tons. The royalty from this source was never to be less than £50,000 up to the end of the tenth year and £75,000 afterward. The first payment was to be made at the end of the sixth year. At the end of three years the company was required to select two provinces for exploration and by the end of the fifteenth year a maximum area of 100,000 square miles for development.

While the concession of the Inland Exploration Company included the right to search all Afghanistan for oil, five provinces were to be chosen eventually, and the rights to the latter covered a period of 60 years from date of ratification. Here also, the company was obligated to make an effort to reach a production of at least 6,000,000 tons of oil per annum. A royalty of four shillings per ton was fixed, but whenever the London gold price exceeded £6 per troy ounce, company payments were to be augmented $\frac{1}{1440}$ for each penny of increase on the day marked for payment. Regardless of the status of operations, the total annual payments to be made to the government after the last quarter of the fifth year was never to be less than £280,000 ($1,400,000). After the fourteenth year the minimum payments were to be £600,000 ($3,000,000). Following the discovery of petroleum in commercial quantities the company was to pay $25,000 per annum into a New York bank to pay the expenses of a Royal Government Delegate. After petroleum exports commenced, the company agreed to provide $50,000 per annum for the purpose of giving Afghan subjects a professional education in the United States necessary for the petroleum industry.

Probably one of the reasons for early relinquishment of the concessions was because of the requirements that substantial production be established within the first five years, the alternative being the payment of large minimum royalties. It is obvious that highly prolific fields would have to be discovered and developed with great rapidity in order to avoid these penalty payments.

Under the terms of the Iranian Pipe Line Company agreement, the government of Iran granted the company a non-exclusive right to construct and own pipelines to terminal points anywhere in Iran with due respect to the rights previously granted, or granted in the future to other companies. Rights to construct refineries were also included in this concession. Conditions of the contract enable a pipeline to be constructed in Afghanistan and joined to the one in Iran and so make a bifurcated line as indicated on the large map published with this issue of WORLD PETROLEUM.

While the pipeline concession was for a term of 60 years the company was granted complete exemption from taxation for 30 years in return for payment to the government of three pence per metric ton on all oil passing through the line.

These concessions may be now available to other oil company groups, but it is hardly to be expected that they will be acquired under the same terms because of the availability of lower cost oil in other parts of the Near and Middle East. Assuming suitable modifications are made, it will not be surprising to see several applications for the concessions. It is to be borne in mind that, regardless of the fact that crude oil production today is capable of exceeding demand, all indications are that the demand in another 10 or 15 years will be about double the present output. For 60 years production and consumption have shown an average annual increase of a little over eight percent per annum except for slight drops in 1931 and 1932. Production in 1937 was 2,025,000,000 bbl. and because of the road construction programs in many countries and the steady increase in motor traffic, consumption for 1948 will probably be closer to 4,000,000,000 bbl. This means that vast new fields must be found and developed prior to this time.

Frederick G. Clapp, geologist for Amiranian at Jaban en route to Gurgan.

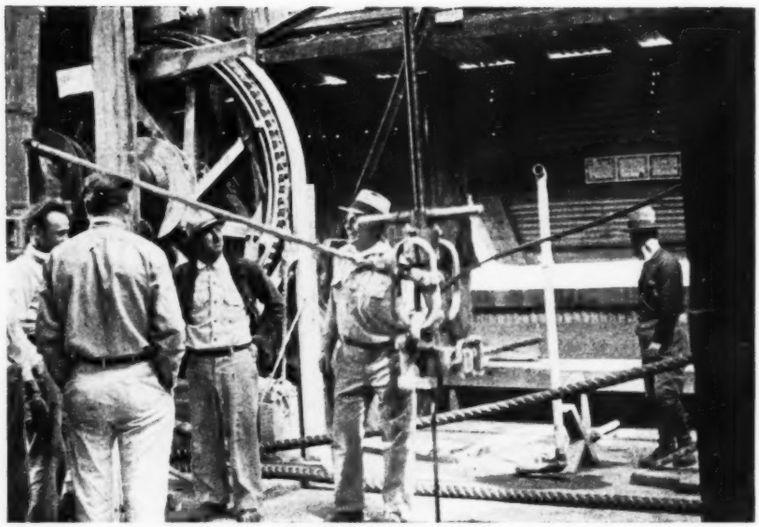
No Commercial Production Results from Million Dollar Campaign IN TURKEY

By William Gilman

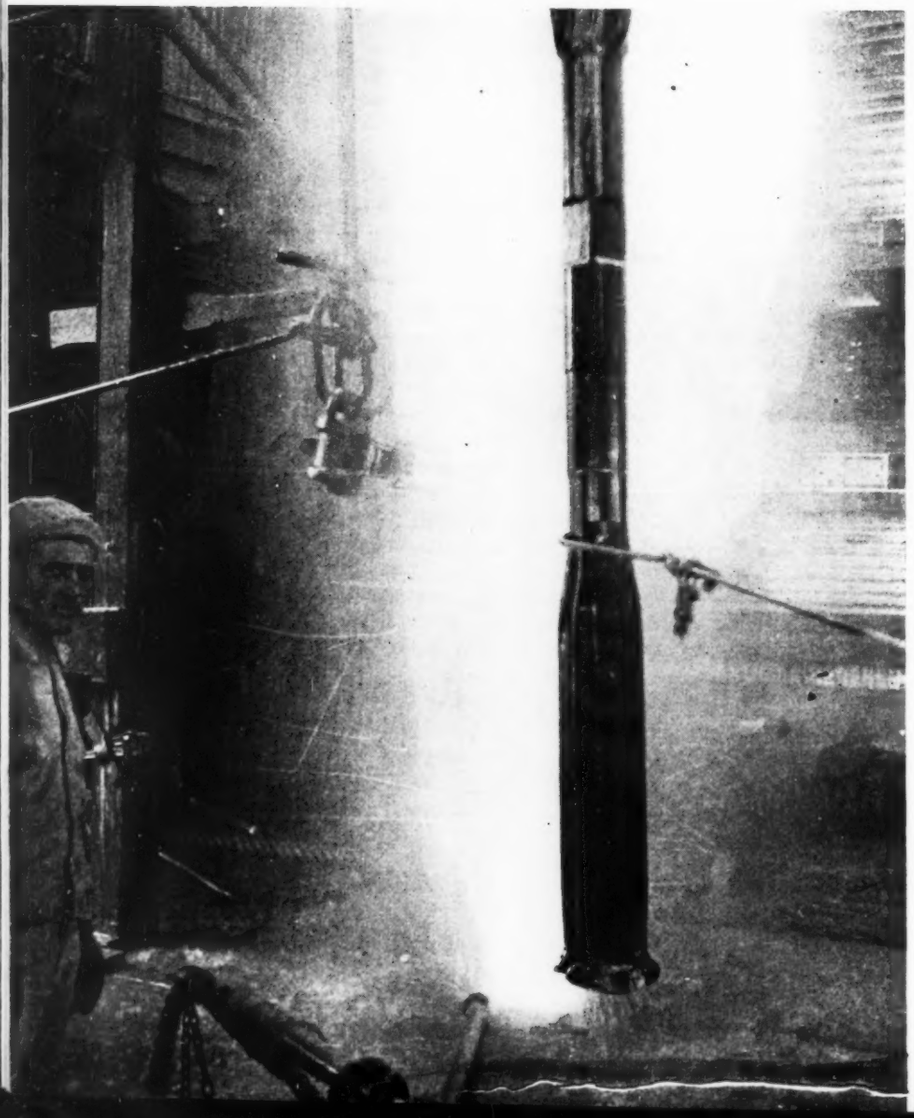
THE sultans of the Ottoman Empire from which the present Turkish Republic sprang once ruled such oil-richness as Mesopotamia, the Caucasus, Egypt, Roumania and Albania. Yet, despite stubborn prospecting in the past few years, Turkey has been able to locate no more than a few non-commercial oil and gas shows.

Since those days, oil has come to a power of its own and the Ottoman Empire has vanished. There remains Turkey, eagerly constructing a type of state socialism under Kemal Ataturk and succeeding to a degree due to her possession of a wide variety of natural resources. But one big requisite for the planned state is lacking, and this in the midst of a region of plenty—oil.

One of the big branches of the government's M.T.A.—the Institute for Mining Research and Prospecting—is the oil section. This is headed by Cevat Tasman, an American-trained petroleum geologist who spent 20 years in Texas and Mexico oil fields for the Doherty and other interests.



Texas drillers in Turkey where intense efforts to find oil are being pursued by the Turkish government.



Gas flowing from the casing head of Hermis No. 1 in Turkey where encouraging shows, but no commercial production has yet been found.

Last year, Tasman and his corps of American oilmen narrowed their search down to three regions. The results are better expressed in the number of wells drilled than the number of barrels found. Altogether, 52 wells were drilled.

Exploration centered in European Turkey, along the Dardanelles where, in the vicinity of Murefte, eight wells were drilled. Good show of gas was found, but very little oil.

Also, in the vicinity of Adana, in the Silician Plain, which is at the southeastern corner of Asia Minor. Here, there was only an evidence of oil.

The third one was the Mardin-Sirt region, where there was only a non-commercial show to reward the drilling of a 2,500-ft. well. The oil consumed by trucks bearing Tasman's equipment to this region far exceeded the oil found.

But the drilling continues in the Mardin-Sirt region, along both sides of the Tigris River, and the searchers expected to keep drilling beyond 2,500 ft. at Hermis No. 1. Tasman, together with his corps of geologists, geophysicists and paleontologists is determined to find oil if it exists in commercial quantities and apparently the

Mardin-Sirt region is the most promising.

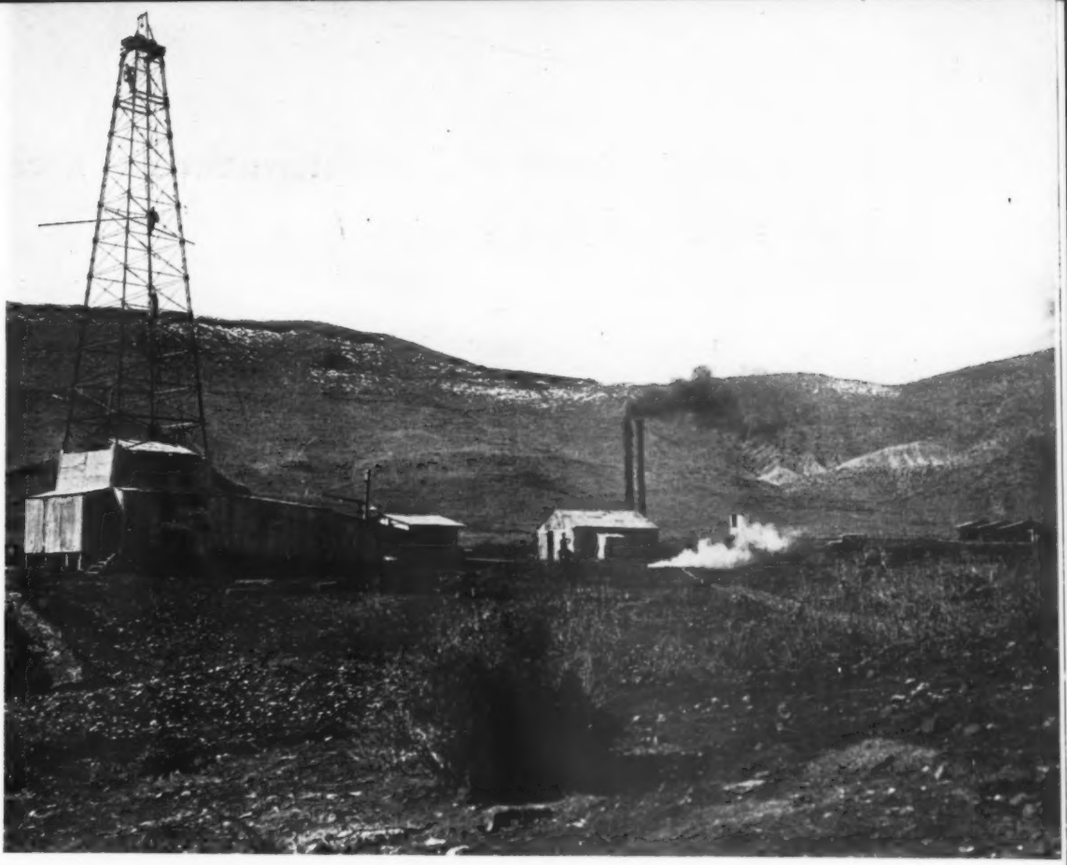
At Mardin-Sirt work is being carried on only a hundred miles or so above the Mosul fields on the Tigris. Northeastward, it is only twice that distance to Russia's rich fields in the Causasus. There is technical evidence aplenty that the Mosul fields do not necessarily end at the Iraq-Turkey border.

So far, the machinery used in this exploration has been American. But Germany's economic drive to the southeast has not stopped at the Dardanelles, and the Turks are particularly susceptible to German bartering agreements.

Speaking of the search for oil in Turkey, Cevat E. Tasman, Director of Drilling Operation, said:

"In less than five years since its creation the agency charged with the duty of ascertaining hydrocarbon wealth of the nation has spent more than $1,000,000, has done extensive exploratory geological work, two seasons' of geophysical work and drilled wells in different parts of the country ranging in depth from 500 to over 4,300 ft., encountering in some cases good shows of oil and gas, some of the latter being of almost commercial value.

"With the progress of the work and acquisition of new information it has been necessary to increase the activity which this year contemplates drilling at five different parts of the country.



Hermis No. 1, most ambitious of Turkish drilling ventures to date. Despite lack of commercial production the government is continuing its search under the direction of Cevat Tasman.

Cevat Tasman, American-trained head of the Turkish petroleum department with Zaro, the camp's mascot.

"Most of the activity is in the structures about the bend where the Iranian range trending northwest turns and assumes an approximate eastwest direction. The section encountered is comparable with that of Bahrain to a remarkable degree.

"To date no commercial oil has been found but optimum conditions coinciding in some of the structures mapped is distinctly probable."

Lack of indigenous production is acutely felt in supplying ever-increasing domestic needs—gigantic government factories, the government merchant marine, the mechanized army with its fleet of heavy bombing planes. Last year, Turkey consumed 40,000 tons of gasoline, a 33 percent increase over the 1936 figure. Most of this went into state and other industrial enterprises, little into the tanks of the relatively few small-car owners.

The M.T.A. will not give up the hunt for lack of money. It is backed by the government-controlled Eti Bank, which has been given a drawing account of £T. 20,000,000 and can get more when necessary. This bank has been made steward of the second five-year plan, which calls for the national development of mining, electrification and agriculture.

There is always in the background, also, the possibility of coal liquefaction. In the matter of coal, with an estimated 2,000,000,000 ton reserve in the Karabuk region along the Black Sea, and with immense deposits of lignite in central Anatolia, Turkey has no need for parsimony.

If more highways were built, or if the tremendous import duty on motorcars was reduced, the situation might be different. But as it is now, there can be little pleasure driving in Turkey—what with the scarcity of good roads, the payment of a customs duty about equal to the price of a medium-priced car, and the cost of gasoline, which is about 45 cents a gallon—of which 75 percent is government tax.

The Turkish oil needs are now supplied almost exclusively by Shell and Socony-Vacuum, who store their supplies in tank farms along the Bosphorus. The situation was once different. Prior to 1935, the bulk of Turkey's oil imports came from Russia's Neft and Roumania's Steaua Romana.

Since then, Russia's exports have dropped —even to so near and friendly a nation as Turkey. And the Turks have diminished their Roumanian purchases, refusing to pile even higher the blocked credits which had reached a total of £T. 2,000,000.

The result is that oil has helped boost American exports to Turkey, which totalled $13,000,000 last year, and of this, $1,000,000 was accounted for by oil and gasoline. Another big item of Turkish import from the United States was bombing planes—$2,500,000 worth—which is merely one indication of why Turkey must have oil.

Successful Completion Stimulates Drilling IN KUWAIT

First Commercial Producer Brought in Early in 1938 Near Burgan Hills—Concession in Sultanate Near Head of Persian Gulf Held Jointly by Gulf and Anglo-Iranian.

AT THE head of the Persian Gulf, near the mouth of the Euphrates River and bordering Iraq, is the small Sultanate of Kuwait. Having an area of only about 6,000 square miles and being entirely desert, with an annual rainfall rarely exceeding four inches, the activities of its Arab population are devoted to things other than agriculture. Pearl fishing is one of the principal industries as is also the building of sail boats (mahailas) from imported teakwood. A considerable trade is carried on with interior Arabia, and much of the tea and sugar consigned to Hail and other north Arabian points passes through Kuwait. Except for the few inhabitants tending date groves grouped about brackish water wells, and occasional Bedouin shepherds, the entire population is found along the coast, chiefly in the town of Kuwait.

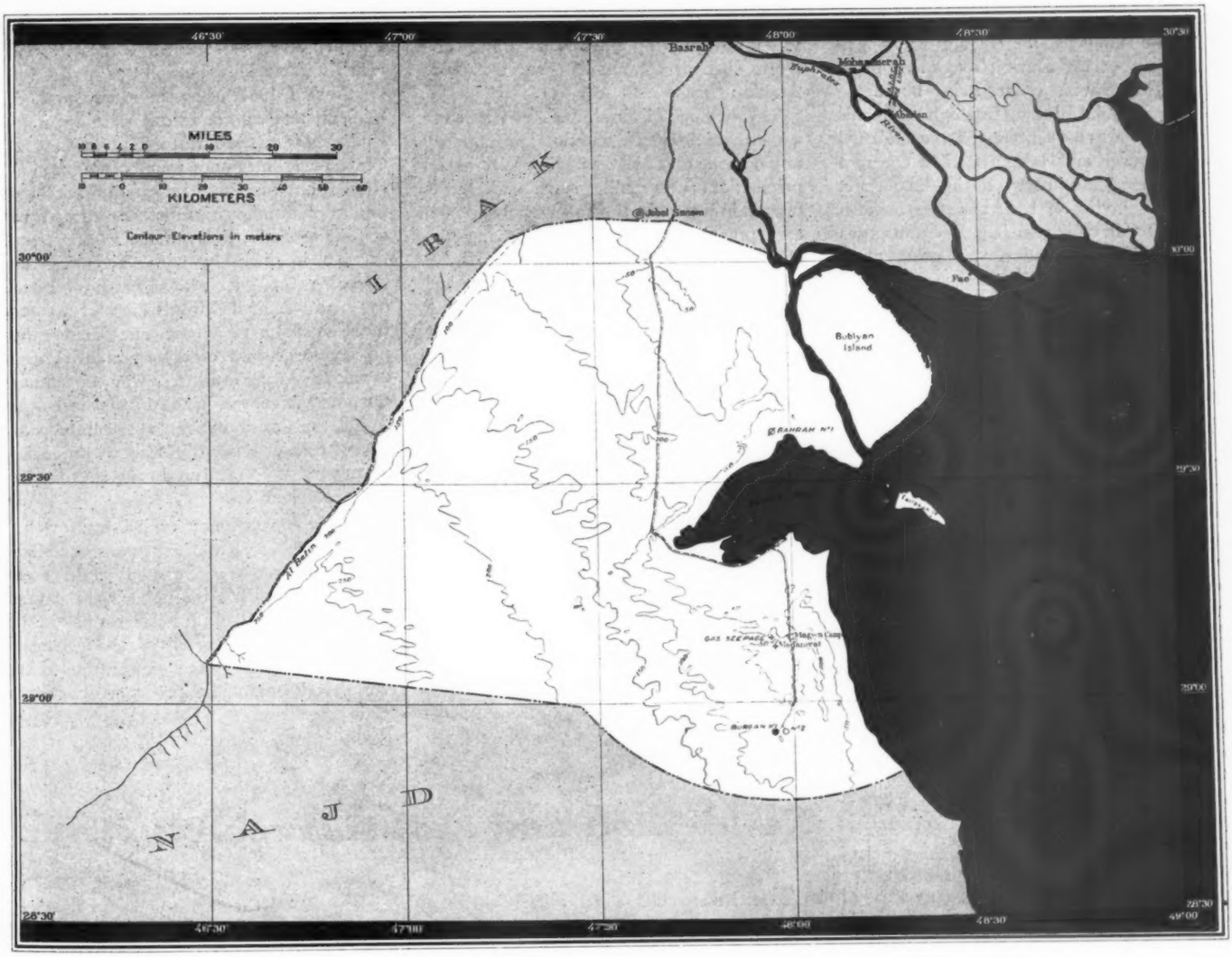
On first impression Kuwait Town with its flat-roofed houses and encircling wall of adobe brick presents the same drab appearance as the country as a whole but, upon closer inspection, the houses are found to be well constructed and one is impressed by the cleanliness of the streets and Bazaar, due largely to the initiative of the present Sheikh Sir Ahmed Al Jabre Al Sabah.

Much of the commerce and industry of the town is carried on along the water front. Arabs, a considerable number of Iranians and negroes mingle together in transacting the day's business, while in the harbor great numbers of mahailas ride at anchor under the protection of the breakwaters or careen on the beach undergoing repair and a dressing of shark oil in lieu of paint. Others move in and out of the harbor engaged in pearling, fishing, or transporting the town's only supplies of fresh water from the Shatt-el-Arab at Fao, in the Euphrates delta.

Being somewhat off the lanes of travel Kuwait until recently was rarely visited by foreigners. Travel into the interior was attended with considerable risk and therefore attempted only by an occasional European explorer bound for the more remote sections of the central desert country.

Although not considered to be under British protection, Kuwait early in the present century sought and received British support in avoiding possible annexation by Turkey. A British political agency is maintained at Kuwait Town, and also prominent among the foreign residents are the doctors and staff of the American Mission Hospital.

In common with most of the Arabian coast bordering the Persian Gulf, Kuwait's petroleum prospects were given scant consideration until about 1923. Seepages of a



Above is shown a map of Kuwait and the surrounding area where the Kuwait Oil Company jointly owned by Anglo-Iranian and the Gulf Oil Corporation is developing a recently discovered oil field. On the left is a picture of Bahrah No. 1, the first well drilled in Kuwait which did not prove a commercial producer. To the right may be seen the waterfront of Kuwait Town.

heavy, viscous tar at three points in the interior have been known for many years but excited little interest on the part of oil geologists, perhaps because all evidence of the underlying geologic structure was effectively mantled by thick deposits of gravel and wind-blown sand.

Major Frank Holmes, a retired British Army officer with long experience in and about Arabia, appears to have been the first to recognize the petroleum prospects of the Arabian peninsula. Representing the Eastern & General Syndicate, Ltd. of

London, Major Holmes began negotiations with the ruling Sheikhs for petroleum concessions covering Kuwait and other areas along the Arabian coast. Being unable to obtain financial backing in England for his venture, he finally interested the Gulf Oil of Pittsburgh and, late in 1927, a contract was entered into between the Eastern & General Syndicate, Ltd. and the Eastern Gulf Oil Company covering the Syndicate's rights in Kuwait and certain other territories in Arabia. Discussions were continued with the Sheikh of Kuwait and the British Colonial Office in an attempt to work out a satisfactory contract agreement covering the petroleum rights in the Kuwait territory. Little was accomplished during the succeeding four years and at about the time the Standard Oil Company of California began drilling on Bahrein Island, the Anglo-Iranian Oil Company began a geological investigation of Kuwait and, in the period 1931-1932, drilled two shallow core holes, the first near the Bahrah oil and gas seepage north of Kuwait Bay, and the other near Burgan Hills about 30 miles south of Kuwait Town. Results were inconclusive as the depth reached was insufficient to penetrate the Kuwait formation of Miocene age. However, commercial oil production had then been proved on Bahrein Island in formations known to be present beneath the Miocene strata in Kuwait and the Anglo-Iranian Oil Company became a competitive bidder for the Kuwait concession rights.

Little progress was made by either company in the negotiations until almost three years later when the Anglo-Iranian Oil Company and Gulf Oil Corporation formed the Kuwait Oil Company, Ltd. with ownership divided equally between them. Through this company a petroleum concession covering all of Kuwait territory was signed December 23, 1934, and shortly thereafter a party of British and American geologists began geological studies to determine the location for the first well.

Evidences of anticlinal folding in the Miocene strata north of Kuwait Bay influenced the decision to locate the first test well at Bahrah near the site of a prominent oil and gas seepage.

As no other deep wells had been drilled anywhere in this region and considering the scarcity of fresh water, it was deemed advisable to order a combination rotary and standard cable tool drilling outfit powered by gasoline engines. A complete camp, including quarters for the Arab workers, was erected near the well site and by the latter part of May, 1936, everything was in readiness to begin drilling. The spudding-in ceremonies were attended by H. E. Sheikh Sir Ahmed Al Jaber Al Sabah and about one hundred and fifty visitors from Kuwait Town. However, the dignity of the occasion was interrupted by a heavy wind and sand storm such as commonly occur along the Arabian coast.

The drilling of Bahrah No. 1 continued to a depth of 7,950 ft. without encountering any oil zone capable of yielding commercial production. After making some further tests of certain intervals, the hole was abandoned and preparations made for moving the equipment to the second location.

An extensive campaign of geophysical surveys was begun in September, 1936, by crews of the Gulf Research & Development Company, of Pittsburgh, using magnetometer, gravimeter, and seismograph instruments.

In planning such work consideration must be given the climatic conditions as high humidity and intense heat in the lowland country during the period from May to September make it inadvisable to attempt any continuous field investigations during the summer months.

By May, 1937, the entire territory had been covered by gravimetric survey and the more promising gravity features investigated with the seismograph. The second drilling site was determined according to the final interpretation of the geophysical results and located in the southern part of Kuwait, 30 miles south of Kuwait Town, near Burgan Hills. The well was spudded in October 16, 1937, using the rotary method. Difficult drilling conditions were encountered almost at the surface. The Eocene and Cretaceous limestones were so porous that circulation was lost repeatedly and the formation of mud rings further retarded the drilling progress. Below 3,400 ft. the strata became more shaly with increasing oil shows. At 3,671 ft. a high pressure oil and gas sand was drilled into which for a time, threatened to blow out but finally the pressure was overcome by weighting the circulating fluid and a string of casing cemented just above this oil-bearing interval. Production tests indicated a commercial rate of flow of crude oil of about the same character as that produced from the Bahrein Island field.

Preparations are now under way for the drilling of a second well in the Burgan area located about one and one-half miles east of Burgan No. 1. Although several wells must be drilled to outline the extent of the pool, sufficient is known of the geologic structure to justify the expectation that Kuwait will become an important source of crude petroleum.

Naft-i-Shah and Naft Khaneh Oil Fields

Two lesser oilfields in the Middle East, Naft-i-Shah and Naft Khaneh, straddle the borders of western Iran and the Transferred Territory. They are really one oil field operated by two companies, the dividing point between operations being exactly on the border line. From Naft-i-Shah a 158 mile three-inch pipeline to a refinery near the town of Kermanshah, Iran was completed in 1934, while a 25-mile line from Naft Khaneh serves a small topping plant located on the bank of the Alwand River near Khanaquin in the Transferred Territory. The two companies are controlled by the Anglo-Iranian Oil Company and neither the crude nor refined products are exported to the Mediterranean, but are used to supply local consumption requirements.

Naturally the field is being economically developed as one unit; but a part of it was the subject of a pre-war agreement between Iran (then Persia) and Turkey in regard to an exchange of land under which Iran handed over to Turkey the area at Naft Khaneh. After the war this area—known as the Transferred Territory—became part of the Kingdom of Iraq.

Under the terms of the D'Arcy concession of 1901 the Anglo-Persian Oil company (now the Anglo-Iranian) acquired rights over this area, which were safeguarded under the transfer to Turkey and later to Iraq. The company carried out exploration operations and eventually proved the existence of an oilfield on this international boundary, wells having been brought in on both sides. The Naft Khaneh field was transferred to the Khanaqin Oil Company in 1925, while the Kermanshah Petroleum Oil Company was formed in 1934 for the purpose of developing the Naft-i-Shah field, building a pipeline and refinery.

The pipeline was laid through very broken and hilly country, rising from 500 ft. to over 5,000 ft. at one point necessitating digging the trenches by hand labor instead of by trench diggers. Winter and summer shade temperatures range from zero to 120 deg. F. There are four pumping stations on the line. Three are driven by 45 b.hp. Diesel engines—nine units all told—and one station is powered by steam. All pumps are of the horizontal high-pressure reciprocating type. In each station there also are Diesel generating sets for lighting and fire extinguishing services.

HIGH PRESSURES Impede Progress of Indian Oil Production

BRITISH India has within its boundaries some of the oldest oildfields of the Near and Middle East. Punjab and other Indian provinces along the Afghanistan and Baluchistan borders, hold forth considerable promise of greater oil production. Output has never compared with that of Burma, to the east, but development of the area has been appreciably retarded due to the unusually high pressures encountered. This is especially the case with regard to the Khaur field, where pressures exceed those found elsewhere in the world.

GEOLOGY

The known commercial petroleum resources of the Indian Empire are confined to the sites of three ancient gulfs: (1) the Burmese gulf, covering what is now the basin of the lower Irrawaddy and its main tributary, the Chindwin, and opening into the Bay of Bengal; (2) the Assam gulf, occupying the middle portion of the present Brahmaputra and debouching into the Bay of Bengal via the modern Meghara basin; and (3) the Punjab-Baluchistan gulf extending along the base of the Himalayas northwest from a point opposite Naini Tal and coming round through the Potwar plateau south-southwest, through what are now the Baluchistan hill ranges, to the Arabian Sea.

In all these areas the oil is associated with the Tertiary strata. Petroleum is known to occur in beds of Nummulitic age in Burma and Assam, but by far the greatest number of seepages, and all the fields of importance, are in the next highest geological series, to which there is every reason to suppose the oil is indigenous.

On the other hand, in the Punjab it is the Nummulitic which is the predominant oil yielding series, and although the only commercial supplies which up to 1936 had proved of economic importance were found in the series above, it was justifiably supposed that the oil had migrated from the Nummulitic below.

There are numerous indications of the presence of petroleum in the Punjab and Baluchistan, but often either the structure is so compressed as to prevent the accumulation of large deposits, or the petroliferous horizon has been deeply eroded. Promising structures have been carefully tested but up to 1936 Khaur remained the only source of commercial production. Dhulian was proven as a promising source of petroleum in that year.

Production at Khaur was 98,896 bbl. in 1936 compared with 15,130 bbl. from Dhulian. In 1937 the relative positions were reversed, and despite the fact that Dhulian production did not benefit over the whole of the year from the output of its two largest wells it amounted to 173,000 bbl. compared with a decline to 77,754 bbl. from Khaur.

HISTORY

Oil springs have been recorded in Punjab since 1848, and drilling was first commenced at Gunda, or Sudkal, in 1861. None of the resultant wells exceeded a daily output of two barrels.

By 1870 the petroliferous region was known to extend over an area of about 900 sq. mi., between Kashmire and Kabul, but the annual output amounted to a mere 54 bbl., at which level it remained for many years. An American group drilled a number of wells in 1887 and onwards, but with indifferent results as the zone proved pocketty.

Several attempts to exploit the petroleum deposits of the Mari Hills at Khattan, Baluchistan, were made between 1884 and 1900 by the Indian Government, having in mind the establishment of a cheap fuel-source for the Sind-Pishin section of the North-Western Railway. Flows of as much as 136 bbl. daily of heavy oil were reported to have been obtained from horizons down to 524 ft. The strata from which production was obtained was of a highly disturbed character and the conglomerate heavily fractured. Although the oil was found to be excellent for the purpose of firing the engines of the railway, the Khattan field was finally abandoned due to flooding of the inadequately cemented wells by the heavy rains. Density of the crude oil was such as to render separation from water difficult.

Likewise, numerous seepages of rich straw-colored oil—naturally filtered—were reported in various parts of Sind; particularly along the river Toi. Oil was indicated near Rohri in 1886 and a test well was drilled to 1,023 ft. in 1894 at Sukkur, southeast of Rohri, but the results apparently did not warrant further drilling.

In 1922 Burmah Oil Company Ltd. was prospecting over a 3,200 acre area in the Kalat district of Baluchistan, apparently with indefinite results. At the same time Whitehall Petroleum Company Ltd. had prospecting licenses over 1,120 acres in North-West Frontier Province and Punjab. Operations began at Jhatla that year and a test well was sunk more than 6,000 ft. The well was not commercially productive at that depth and the field is not of comparative importance as yet.

KHAUR

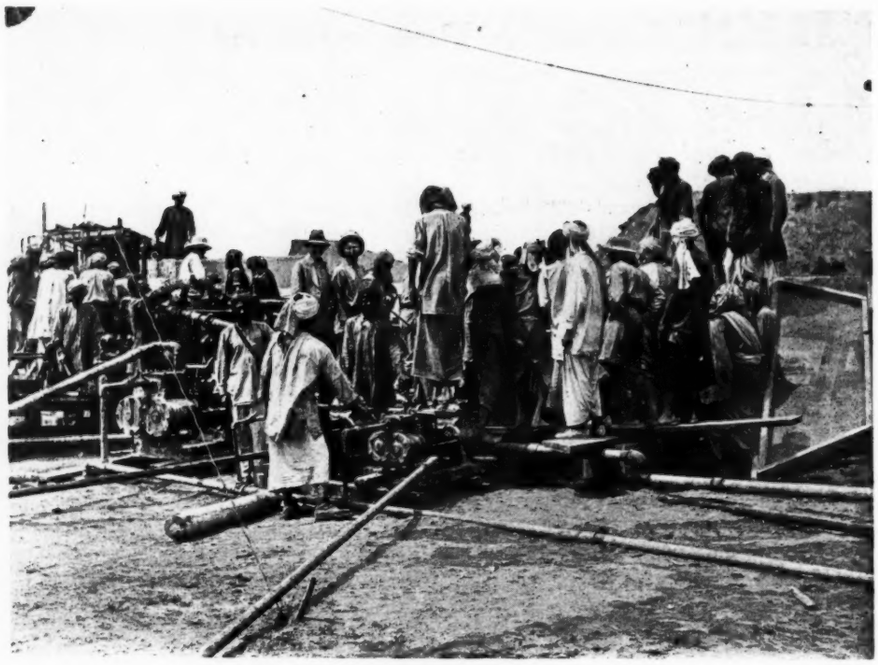
The Khaur region was first tested about 1912, and shallow production was obtained in 1914 from about 500 ft. Production remained small from 1915 until 1922 when a 1,850 bbl. per day refinery was put on flow at Rawalpindi. At the time production from the older and more important Burmese fields was on the decline, but output of the Punjab (Khaur) jumped from 1,647 bbl. in 1921 to 204,509 bbl. in 1922. This compared with a production of 8,491,201 bbl. and 8,291,729 bbl., respectively, for the whole of India and Burma. The Khaur field reached a peak production of over 530,000 bbl. in 1929, but from that point declined steadily until output was a mere 77,000 bbl. in 1937. Although the field was one of definite commercial production it was not of major importance.

In structure the Khaur field is an elongated, slightly asymmetric dome. The maximum dip on the flank is about 45 deg. while the gentle pitch attains an angle of about seven degrees. The structure is exceptionally regular and correlation of the various producing horizons is simple.

About 1930 it was decided that the oil obtained was but fissure oil, and that there were excellent prospects of more stable production once the parent reservoir had been tapped. At the time output was primarily from the 3,800 ft. sand, although a number of shallow wells varying from 100 to 500 ft. have given small additional production up to the present day. The oil is thought to have originated in Eocene rocks and to have migrated up through the younger Murree beds above.

Because of the unusually high pressures encountered, the depth drilled in search of deeper producing horizons is a matter of considerable technical difficulty, although the experience obtained over the past five years has enabled Attock Oil Company Ltd. eventually to master these problems.

Even the shallowest beds in the Khaur field gave evidence of relatively high pressure, oil sands at 100 to 500 ft. from the surface yielding flowing production in the early stages of exploitation of the field. Cable tools at 1,300 to 1,900 ft. could not be controlled by columns of water and the



In India a swarm of native labor assists at the connection of pumps for a cement job.

realization gradually grew that the pressures to be dealt with considerably exceeded what would be experienced were they due to simple hydrostatic conditions. At 2,800 ft. rotary wells could not be controlled by mud fluid weighing 80 to 90 lb. per cu. ft. and serious blow-outs occurred.

Down to about 3,200 ft. sandstone predominates greatly over shale, and the holes did not cave at all badly after release of pressure by a blow-out. Wells could be allowed to flow uncased for several hundred feet and without being beaned at the surface. Below 3,200 ft. the predominant formation is shale, and where much of this is exposed any sudden release of pressure causes caving to ensue—frequently to a dangerous extent.

A marked increase in rock pressure below 3,500 ft. necessitated use of master valves, blow-out preventors and mud discharge Christmas trees.

Since about 1932 Attock Oil Company Ltd. (latterly assisted financially and technically by Burmah Oil Company Ltd.) has concentrated its efforts in the Khaur field on deep tests rather than shallow wells. In one of the earliest of these a 750 bbl. flow was obtained at 4,898 ft., but a violent upheaval occurred and the casing was plugged to within 1,000 ft. of the surface. Heavy pressure prevented cleaning out the well. These tests have been greatly hampered by the problem of overcoming excessive pressures. Some wells show pressures of 2,750 lb. per sq. in. while there have been instances of control pressure plus mud-column pressure equalling or exceeding 5,000 lb. per sq. in.

In such a case from 5,215 ft. to 5,478 ft. the control pressure had to be kept at 1,800 lb. per sq. in., using 90 lb per cu. ft. mud fluid, in order to prevent the well from yielding water. The rock pressure at 5,215 ft. may therefore be calculated as 5,060 lb. per sq. in.

Later this formation apparently became sealed off, as after the 5,300 ft. sand had been struck, at 5,478 ft., it became necessary to use a still higher control pressure, and this proved possible without loss of water from the mud. From 5,478 to 5,693 ft. the control pressure had to be maintained at 2,000 lb. per sq. in., with 90 lb. per cu. ft. mud, to prevent a gain in volume of the circulating fluid. The rock pressure at 5,478 ft. appears therefore to be about 5,420 lb. per sq. in., indicating that increase in pressure averages one pound per foot of depth.

The first deep test well at Khaur was drilled successfully to 5,887 ft. in 1933. Small quantities of oil were found in the limestones encountered at 5,600 ft., while there were indications of gas and oil in the strata immediately overlying the limestones. Encouraged, Attock prepared further deep tests, and subsequently inaugurated a systematic program of deepening its old wells at Khaur to the 5,400 ft. level, which had been proven productive. But it was obvious that to succeed in getting through the high pressure water zone that it was necessary to hold pressure on the wells constantly.

In view of the necessarily heavy commitments for deep drilling plant and drilling expenditures generally, the Attock Oil Company Ltd. found it desirable to avail itself of the offer of finance that Burmah Oil Company Ltd. had made some time before, and in May 1936 that company advanced £50,000 against debentures bearing an interest at six percent. Another £50,000 was advanced at the end of 1937. Attock has a call for further finance within the limits of £200,000 until the limestone formation should be tested to the satisfaction of Burmah Oil Company.

The work of drilling against high pressures required special plant and staff, with the result that the company was precluded from drilling more than one well at a time through the pressure zone. Drilling to the shallow sands at 500 ft., which was inexpensive, gave profitable results and helped offset decline of older wells. Intermediate drilling to 1,600 ft. did not prove profitable but gave indications that certain sites were worth further exploring.

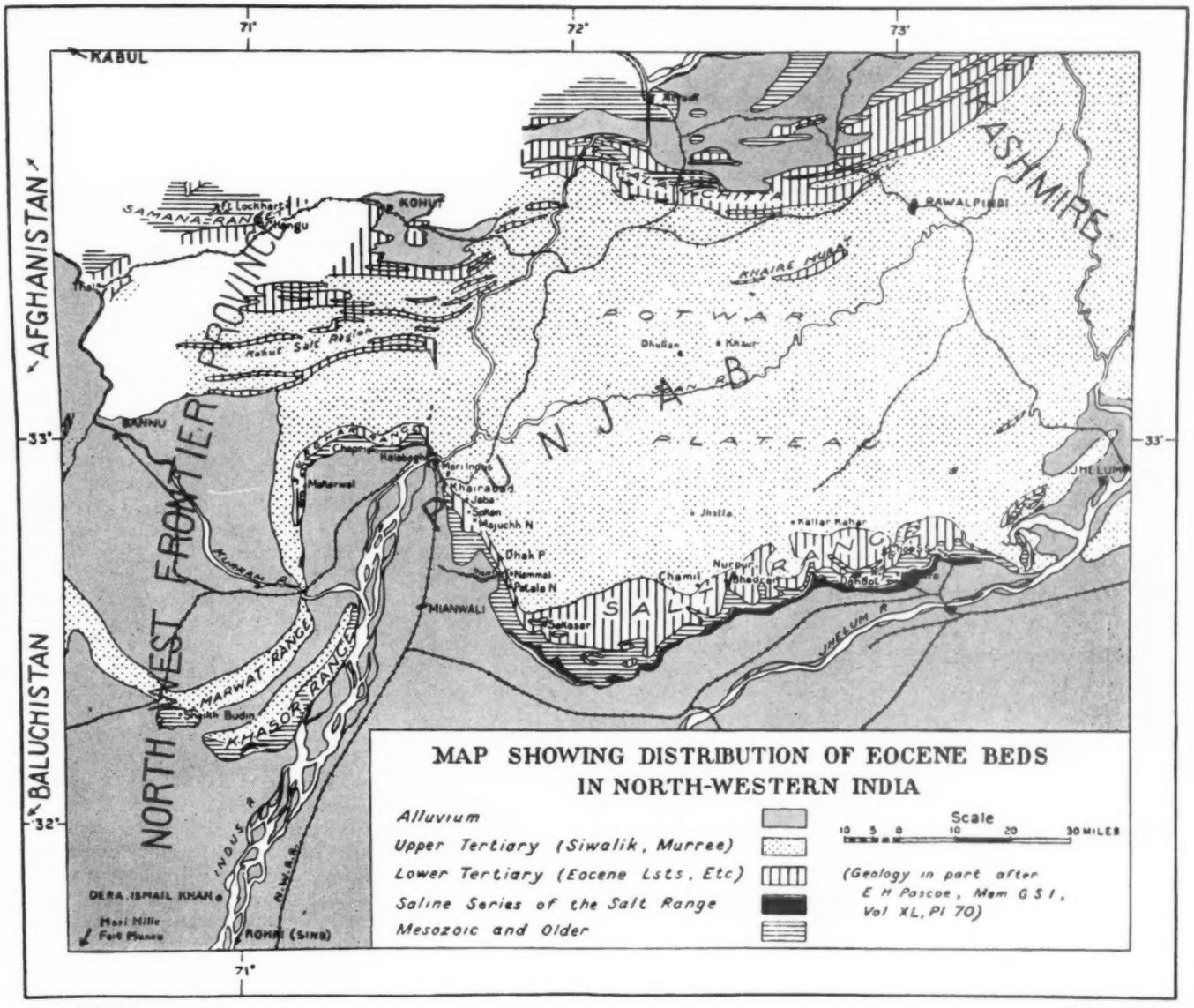
In October, 1935, a well had been successfully brought-in at 5,408 ft. with an initial flow of 250 bbl. daily, but in nine months had declined to about 45 bbl. per diem. This decline was evidently due to caving, and rehabilitation was left until men and equipment could be spared from the other test wells.

In the company's progress report of January 28th, 1937, three deep wells were mentioned—**A, B,** and **C.** Of these, **A** had ceased flowing due to collapse of the casing and repair work was postponed; in view of the existing circumstances it might have proved uneconomic.

B had produced between July, 1936, and June, 1937, some 20,000 bbl. at the end of which time the average was about 42 bbl. daily. The drop in production did not appear to be normal, but here again the company preferred to leave the well depending further results.

Well **C** illustrates again some of the problems encountered in overcoming the high pressures, for, when on the point of running the casing, a new high pressure fitting blew out, resulting in the drill pipe sticking. Its recovery holed the casing. Thus, even with what is supposed to be the best of plant, the company is never certain that it will withstand the pressure. After reaching 5,575 ft. this well again got into such serious difficulties that it was decided to proceed with well **D.**

This further deep test to the limestones, referred to as well **D,** was located at a site chosen in conjunction with Burmah Oil Company Ltd. and has been drilled with a special casing program to endeavor to ensure as far as possible that it gets down to and tests the main limestones—below the then deepest producing zone. This well



Davies & Pinfold *G. S. I., Calcutta.*

The Eocene beds of the Punjab salt range—based on a map drawn for and published in the Records of the Geological Survey of India by T. O. Morris, geologist of the Indo-Burma Petroleum Co., Ltd.

explored the possibility of additional oil-bearing beds occurring at greater depths, and the prospects of the Khaur field to the south. It may require to be drilled to more than 6,000 ft. before it will have passed through all the strata in which oil may occur. Progress was somewhat slower than normal, as it was essential to keep the well straight and prevent it from drifting northwards. According to the progress report of June 1938, it had been cemented successfully and is being tested at 5,440 ft. in limestone. Results so far are disappointing, the well showing a considerable quantity of water with only a small amount of oil, and it does not promise to be an important producer.

DHULIAN

Dhulian, seven miles west of Khaur, has also been the seat of deep tests against high pressures. Despite the fact that the producing zone is 2,000 ft. deeper, drilling is easier because the deep high pressure water zone is not present, and the results to date give promise of much more reliable and sustained production than that obtained at Khaur.

Interest in this part of Attock's property is comparatively recent, although some testing of shallow production had been carried out as early as about 1922. Appreciable difficulties were encountered in later years as greater depths were penetrated.

Attock's fifth test well in this area was commenced in October, 1934, and the company's geologists believed it likely that it would be necessary to go 7,000 to 7,500 ft. deep in order to test the limestones. The first indication of oil was reported at 7,448 ft. in September, 1935, and the well was deepened carefully to 7,501 ft. and at the beginning of November flowed under low pressure at 100 bbl. of oil daily. This oil was heavy and not so valuable as Khaur crude.

This strike was tested for one month and production held up satisfactorily. The well was then deepened, as it was apparent it was not yet into the limestones. The well was drilled with oil circulation to 7,653 ft. and the oil production thereby recovered. Thereafter mud circulation was necessary to deal with caving formation and the well was deepened steadily to 7,852 ft., at which depth new oil was struck which flowed at

(Continued on page 128)

INTEGRATED INDUSTRY

May Develop in Palestine

By A. E. Mulford

Consumption Increasing, Marketing Being Modernized, Exploration Active, Palestine May Soon Need Only a Refinery to Possess a Fully Integrated Petroleum Industry.

CONSUMPTION of crude and fuel petroleum, benzine and other products has increased considerably in Palestine during the last three years, and during 1937 the value of imports of benzine, kerosene, lubricating oil and fuel oils amounted to £P.750,000.

Palestine Imports
(In metric tons)

	1935	1936	1937
Kerosene	46,574	48,202	49,204
Benzine	38,068	32,850	40,887
Petroleum, Crude and Fuel	62,503	81,958	87,921
Asphalt, Tar and Pitch	9,700	9,795	15,328
Lubricating oil and grease	4,135	2,682	4,039

Conditions of insecurity in Palestine were reflected in the decrease of imports shown for 1936. It should be remembered that 1935 was a period of peak economic development in this area, so that for the purposes of comparison the years 1936 and 1937, marked by the economic slump which resulted from political uncertainty, can hardly be taken into account.

Yet, there was some compensation in the higher transport needs of the military garrison, augmented since 1935, and of the Royal Air Force. Moreover, fuel oil is now being used to a much larger extent in the heavy industries of the country, which have seen expansion during the last two years. These are principally the Palestine Electric Corporation stations, the Jerusalem Electricity and Public Services Corporation, and Palestine Potash Limited.

The increased imports of asphalt, tar and pitch resulted from the extension of the country's road system.

Delivery of benzine to consumers during the past three years has been gradually transferred from tins to service stations and filling-pumps. There are now over 100 filling-stations dotted throughout the country for the convenience of individual automobile owners and consumers. The modernization of building construction in Palestine has also brought about an augmented use of oils for central heating plants.

The principal importing and marketing companies are the Shell Company of Palestine Ltd., the Socony-Vacuum Oil Company Inc. and the Société du Naphthe S. A. (A. I. Mantacheff et Cie.).

Prices during 1937 were slightly higher than in 1936 as a result of firmer Roumanian prices f.o.b. Constanza. The average price of kerosene throughout last year was about 80 cents per four gallons, on which a customs duty of 15 cents was paid, and for gasoline roughly $1.90 per four gallons in bulk ex-pumps, on which $1.00 per four gallons was levied.

A considerable fillip would be given to local consumption should a new refinery be erected in the Haifa Bay zone. With a possible decrease in the excise duty on locally-refined products, there would be a development in motorized traffic and in the use of industrial machinery.

Among other important sources of increase has been (and will be) civil aviation. In addition to the various military landing-fields dotted about the country, there are now airports at Lydda, in the coastal region near Jaffa, and at Haifa, while Haifa Bay and the Sea of Galilee provide seaplane bases. The airlines using Lydda are Imperial Airways, K.L.M. (Royal Dutch Airlines), L.O.T. (Polish Airlines), Misr Airwork (Egyptian Airways), Palestine Airways and the Palestine Aero Club. Ala Littoria (Italian), which maintains a seaplane service with Brindisi, uses Haifa harbor, while Imperial Airways has its flying-boat base just off Tiberias on the Sea of Galilee. The Shell Company is contemplating the building of a bulk storage depot for aviation fuels at a point near Lydda airport, now a link in the Europe-India-Far East route.

There is also the important consideration to be remembered that British naval authorities are said to have long had their eye on Haifa as a naval fueling base, and no doubt the provision of a refinery would bring that plan a stage nearer.

Present exports from Haifa, as the southern terminal of the Iraq oil pipeline, are about 2,000,000 tons per annum of crude oil. A similar quantity is shipped from Tripoli, in Syria. In some circles, however, the view is rife that there may be oilfields in Palestine itself.

When Petroleum Development (Palestine) Ltd. was founded by the group of leading oil interests associated in the Iraq Petroleum Company Ltd., it indicated the preparation for the opening of what might possibly be a new era in world oil history—and incidentally a stroke of prosperity for the Holy Land.

Bible readers were by no means surprised to learn of the probable existence of oil reservoirs under the surface of hallowed soil, citing two instances to demonstrate their faith. Moses, it will be remembered, caused "bitter water" to flow from a rock at Mara, in the Sinai desert, while Elijah in his wrath threw water over the altars of the gods of Baal on Mount Carmel and a bolt of lightning caused the water to burst into flames. A mechanistic reasoning might indicate petroleum instead of miracles.

Not many miles away from the place where Moses enacted the miracle of "water from a rock" is the famous Negeb, or southern district of Palestine, where geologists believed there are promising structural features for the accumulation of subterranean oil reserves.

A large oil structure of this kind was recently located near Gaza, and Petroleum Development (Palestine) Ltd. has obtained drilling licenses from the Government. Another favorable region is reported to lie in the neighborhood of Qurnub, south-west of the Dead Sea, and more structures have been recorded in that region.

According to a local expert, Dr. A. Loehnberg, writing on Palestine's oil future in the local PALESTINE AND MIDDLE EAST ECONOMIC MAGAZINE, there are favorable petroleum prospects in the Negeb; and he dwelt at length on the immense reserves of bituminous limestone (having an oil con-

A Shell service station in the new Jewish suburb on the slopes of Mount Carmel is shown above while to the left may be seen a close view of the world famous trademark surmounted by modern Hebrew sign. To the right an Imperial Airways seaplane being refueled on the Sea of Galilee with snowclad Mt. Hermon in the background.

tent of five percent to 25 percent) which total at least 200,000,000 tons in various parts of the country.

Other experts, however, say that this is not a commercial proposition, although German military engineers, during the Great War, erected a plant in Northern Palestine for the distillation of petroleum from the bituminous beds. Pure bitumen, floating on the Dead Sea among its other minerals of potassium, bromine and magnesium, is believed to spring from an underground fissure beneath that great lake.

If Palestine were indeed eventually to become an oil producing center, its strategic significance to the British Empire would be increased, as a good supply would then be available in the event of the Mosul-Mediterranean pipeline being cut off by an emergency. Haifa is the nearest point to Marseilles and France, being half the distance from the next nearest port of despatch, Constanza on the Black Sea.

EGYPT Offers Encouragement to Bolster Declining Production

Revised Regulations Adopted by Government Have Stimulated Intensive Exploration in Which Leading International Companies Are Participating—Numerous Concessions Granted.

For a quarter century past oil has been produced in Egypt to a limited extent. Production has been in the hands of a single company, Anglo-Egyptian Oilfields Ltd., affiliated with the Royal Dutch-Shell group. Since the introduction, last year, of new regulations governing exploration for and exploitation of petroleum, renewed interest has been aroused in Egypt and new activity has resulted, not only on the part of Anglo-Egyptian but also on that of other large international companies who have applied for and received concessions.

Companies to which prospecting licenses have been granted by the Survey and Mines department of the Egyptian government or which have applications pending include the following:

Anglo-Egyptian Oilfields Ltd. (Shell group)
D'Arcy Exploration Co. Ltd. (Anglo-Iranian)
Socony-Vacuum Oil Company
Standard Oil Co. of Egypt (Standard Oil Co. of New Jersey)
Soc. California Egyptienne des Petroles (Standard Oil Co. of California)
Soc. Texas Egyptienne des Petroles (The Texas Corp.)

Zakki Bey Wissa (Egyptian Oil Syndicate, now in the hands of the Banque Misr) has also been granted an area at Abu Durba, which was first opened up by the Survey and Mines Department.

That it is the intention to explore Egypt thoroughly for new oil sources is evident from a study of the accompanying maps on which are shown the areas over which licenses to prospect have so far been granted. Applications for other areas are also awaiting official approval, and it is understood that several companies of the "Shell" group, Romano-Americana (Standard of New Jersey), Anglo Iranian, Belpetrole, St. Paul Petroleum Corporation (Standard of New Jersey) and Agwi Petroleum Corporation (Standard of New Jersey) have applied for licenses over areas mainly along the Mediterranean coast west of Alexandria and in Sinai. All participants in the search are taking active steps to prospect their areas.

Anglo-Egyptian Oilfields, Ltd., started prospecting work at Ras Ghareb, about half way between Suez and Hurghada, September, 1937. Several unsuccessful attempts had been made in this area a decade ago. They hoped, that with the new technique available their efforts would be rewarded.

A progress report early in the year mentioned traces of oil having been discovered. In April it was announced that the Ras Ghareb well had been completed at 2,560 ft., cleaned out to 2,500 ft., and tested for 48 hours. It produced during that period 2,044 bbl. of crude, with a specific gravity of 0.923, with 3½ percent water, which has since declined to ½ percent water.

The discovery is sufficient to warrant erection of storage tanks, pipeline, and harbor facilities on the near-by coast for transporting to Suez for refining.

Under the prospecting license, only test shafts may be sunk, and no petroleum raised except for use in prospecting operations. Once prospecting is completed, the company obtains a mining lease for 30 years, with the option of renewal for a further 15 years. Granting of the lease is purely a formality.

Several of the other companies are preparing to test their areas with the drill. Socony-Vacuum is believed to have selected a site at Dishel el Baba, which is at the upper end of the concession which lies directly north of Safaga Island.

Egyptian Crude Oil Production

Year	Thousands of barrels	Year	Thousands of barrels
1911	21	1925	1,287
1912	200	1926	1,237
1913	93	1927	1,315
1914	715	1928	1,923
1915	210	1929	1,944
1916	415	1930	2,037
1917	980	1931	2,037
1918	2,016	1932	1,937
1919	1,658	1933	1,658
1920	1,058	1934	1,537
1921	1,308	1935	1,258
1922	1,237	1936	1,265
1923	1,093	1937	1,180
1924	1,165	Total	32,784

Petroleum was first produced on a commercial basis in Egypt in 1911 and reached its peak in 1930 and 1931, with an annual output of 2,037,000 bbl. Since the latter year the production has been steadily decreasing. Details of annual output since 1911 are shown in the accompanying table.

Up to the present time only three productive areas have been found and exploited in Egypt—Hurghada, Gemsah and Abu Durba, the latter being on the Sinai Coast of the Gulf of Suez. Today the entire production of petroleum in Egypt is obtained from the Hurghada field, and T. Dewhurst in 1934 (J. Inst. Petr. Techn., 1934, *20*, 281) estimated that Egypt's potential reserve of crude petroleum, based on such geological evidence as was then available, did not amount to more than 10,000,000 bbl.

In the Hurghada field, which is situated at the southern end of the Gulf of Suez, production is obtained from two horizons in the Miocene series and from one in the Cretaceous. The latter, which is found at depths of between 1,600 ft. and 2,000 ft., is the main producing horizon. The Hurghada crude oil is a typical mixed-base crude with a high wax and bitumen content, the average properties being: special gravity at 15 deg. C., 0.907 to 0.925; gasoline, eight percent.; kerosene, 15 percent.; paraffin wax, seven to eight percent.; asphalt (percentage insoluble in pentane), 10 to 11 percent.; and sulphur, 2.2 to five percent.

Gemsah field, which up to the end of 1929 had yielded about 1,250,000 bbl. of oil, obtains its production from two horizons in the Miocene. Since 1929, however, there has been a decline in output from this field and total production in the past eight years has not amounted to more than 35,000 bbl. Average properties of this crude, with a specific gravity of 0.827 at 15 deg. C., are: gasoline, 27 percent.; kerosene, 32.4 percent.; paraffin wax, 4.94 percent.; asphalt insoluble in pentane, 0.63 percent.; and sulphur, 2.35 percent.

In Abu Durba the first well was drilled in 1921 and by 1929 the field was considered to be exhausted. A total of 12 wells were drilled, three of which were productive with a total output of about 30,000 bbl. This crude, which had a specific gravity at 15 deg. C. of 0.945 to 0.960, contained an average of 20 percent. gasoline and kerosene together, 10.5 percent. of asphalt insoluble in pentane, and 2.35 percent of sulphur.

Under the new regulations prepared by the Egyptian Department of Survey and Mines in 1937, three types of permit or license are now granted. These cover sequentially the operations of exploration, prospecting and mining for petroleum.

First of these is the Petroleum Exploration Permit which makes available areas of 100 square kilometres for a period of one year at a fee of £E.10 per annum, with the right of renewal for a further year. The object of granting these permits is to enable holders to select areas for further and more detailed investigation. The number of such areas granted to any one applicant is at the discretion of the Department of Survey and Mines, and from each area the holder has the exclusive right to take out one or more Petroleum Prospecting Licenses.

Each Petroleum Prospecting License covers a minimum area of four square kilometres at an annual fee of £E.25 per square kilometre. Licenses are renewable for a second year on payment of a similar fee and for one further year subject to a payment of not less than £E.100. Renewal is granted only on condition that work has been started and carried on continuously. Of the labor employed it is laid down that 90 percent. must be Egyptian, while 50 percent. of the administrative and technical staff also must be Egyptian.

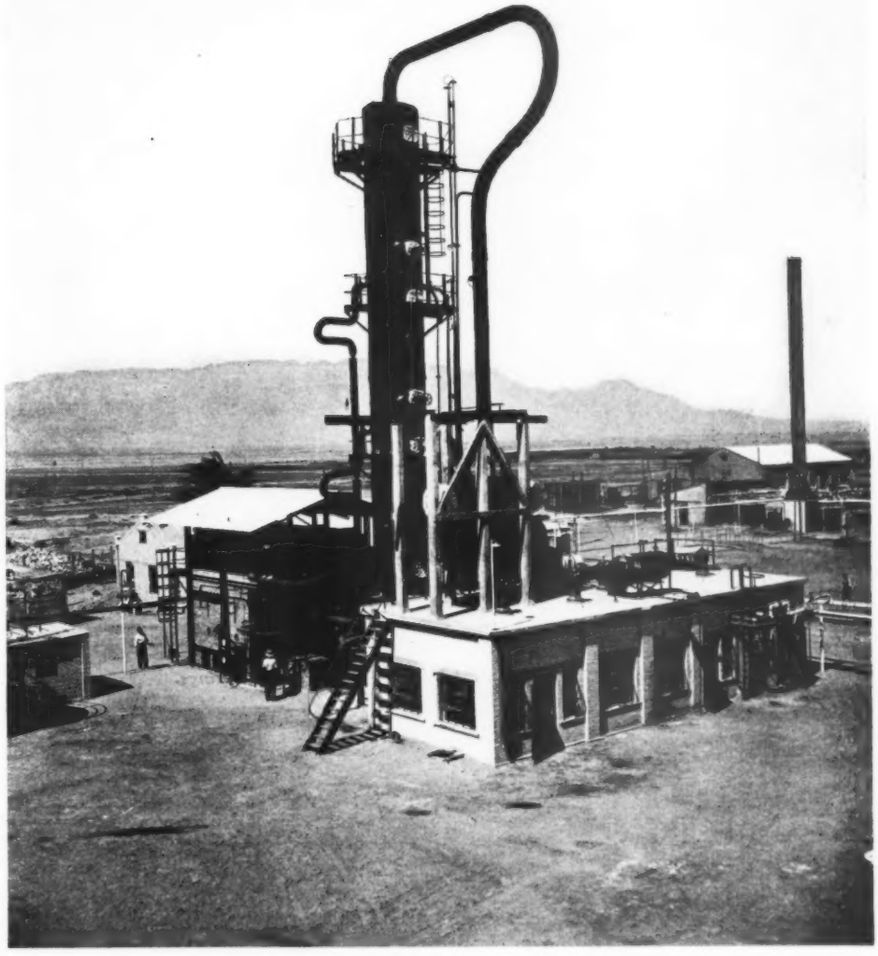
Once oil in commercial quantity is struck it is necessary to take out a Petroleum Mining License, which for 30 years grants over a defined area the exclusive right to produce oil, lay pipelines and carry out ancilliary works. If required, rights will be granted for transport and refining facilities. Rent per year is £E.2½ per hectare, together with a royalty of 15 percent. of the total petroleum saved. Royalty is payable in cash or kind at the discretion of the Department of Survey and Mines.

Since the issue of the new regulations a considerable amount of preliminary exploratory work has been carried out and sufficient knowledge has been gained to enable suitable areas to be selected for further and more detailed work.

Egypt has two petroleum refineries, one owned by the Anglo-Egyptian Oilfields, Ltd., and the other by the Government. Both are at Suez.

Anglo-Egyptian Oilfields refinery, which has a daily crude capacity of about 1,000 tons, operates on the oil produced by the company at Hurghada, augmented by imported crude in about equal proportions. Important extensions are now being made to this refinery and it is understood that the present cracking facilities are being increased by the addition of a new unit. About £250,000 will be spent on making the refinery more efficient and economical in operation.

The government refinery, which was first put into operation at the end of 1922 with a daily throughput of about 100 tons, has been successively enlarged until today



200-ton per day, four-stream, Foster Wheeler topping unit installed at the Government refinery, Suez.

the capacity is about 200 tons per day. Main plant consists of a Foster Wheeler atmospheric topping plant and a Foster Wheeler duo-purpose (atmospheric or vacuum) asphalt unit.

The topping plant has a daily crude throughput of about 200 tons and processes Egyptian or imported crude. The Egyptian crude is that taken from Anglo-Egyptian Oilfields, Ltd., as royalty in kind and tenders for foreign crude are called for yearly and supplies have been treated from various countries, including Iran, Roumania and, latterly, Bahrein. Products include gasoline, kerosene, gas oil, Diesel distillate and a residual fuel oil. The latter can, if necessary, be used as charging stock for the duo-purpose unit. Gasoline and kerosene are subsequently refined in batch agitators by the normal process of acid and soda washing.

The duo-purpose unit operates normally on reduced crude, although fresh crude can be charged if desirable, and produces asphalt and Diesel oil distillate. If necessary reduced crude is purchased for processing in this plant.

The refinery is practically self-contained, the power plant being sufficient to meet all requirements, while there are also efficient workshops and other accessories. A tank farm, with a capacity of about 40,000 tons for crude oil and sufficient for the output of products, is installed. There are also rail sidings and an eight inch pipeline connects the refinery with the petroleum basin in Suez Harbor, about three kilometres distant. About 300 Egyptians are employed on the plant, the only English employees being the Director and the Chief Chemist. Suitable housing is provided for the staff and workmen.

Practically all of the products manufactured in this refinery are supplied to various government departments, although it is understood that certain outside bodies are also able to obtain supplies if desired.

It is reported in Egypt that the government are so satisfied with the results of

(Continued on page 126)

Edward G. Seubert hard at it, chipping burrs off castings.

Foreign Oil Legion

EDWARD G. SEUBERT, president of Standard Oil Company of Indiana, who has pinned many a service pin on employes with due ceremony, received one himself recently. It marked completion of 40 years of continuous service. Actually Mr. Seubert's career with Standard has extended over nearly 46 years, but because he took a year off in 1897 to work with an uncle, only the years since that time have counted toward his emblem. In celebration of the event Mr. Seubert visited the old shop at the Whiting, Ind., refinery where he first worked in 1891. Donning a big pair of overalls he demonstrated to Heaverin Douglas, refinery worker, and to officials with him, how he used hammer and cold chisel in those days, chipping burrs off castings. In the evening the Standard chieftain was guest of honor at a dinner given by the board of directors of the company at Flossmoor Country Club.

REX TOWNSEND, general manager of the Socony-Vacuum interests in Colombia, arrived in New York with Mrs. Townsend June 27th on board the SANTA PAULA.

MAJOR HARRY G. DAVIS, executive of Gulf Oil Corporation (which he represents as director on the board of Kuwait Oil Company Ltd., London), arrived in New York on board the liner PRESIDENT ROOSEVELT June 18th. Major Davis, who is accompanied by his family, is in the United States on vacation. As may be seen elsewhere in this issue, his company recently brought-in a wildcat at Kuwait flowing 2,044 bbl. in 48 hours; the site is about 15 miles from the coast on the Gulf of Iran.

FRANK RAYMOND COATES, president of Cities Service Oil Company and director of a score of other oil, gas and public utility companies comprising the Cities Service group, passed away at his home in Avon, N. J., on June 27th. Death was due to a heart ailment from which he had suffered for several years. Funeral services at Avon on June 30th were attended by a large group of devoted friends, including many men who are prominent in the petroleum and public service industries.

Mr. Coates was born in Philadelphia, June 20th, 1869. He studied engineering in Lehigh University where he was a prominent athlete and after his graduation in 1890 entered railway work in the service of the Baltimore & Ohio Railroad. He advanced rapidly, holding positions of increasing responsibility with several roads. Following service in the Spanish American war he became chief engineer of the Chicago Great Western railroad in 1900 and held that position until 1904 when he resigned to engage in engineering and construction work on his own account. He constructed railway bridges and hydro-electric plants and for two years was associated with Stone & Webster Engineering Corporation.

Following a brief time as president of the Inter Ocean Steel Company, Mr. Coates, in 1911, assumed the presidency of the Toledo Railways and Light Company which was acquired by Cities Service in 1913. The striking success with which Mr. Coates handled the difficult problems encountered in building up the Toledo company marked him as a public utility executive of exceptional ability. In this and subsequent positions he formed friendships with many leaders in political and business life.

Mr. Coates had served as president of the American Electric Railway Association and was a director of the American Society of Civil Engineers, the American Railway Engineering Association and the American Petroleum Institute. He is survived by his widow and one daughter, Helen.

ANDREW AGNEW, C.B.E., managing director, Shell Transport and Trading Company Ltd. and one of the prominent figures in the international oil industry,

Sir Andrew Agnew, C.B.E.

was honored with a Knighthood in the recent distribution of birthday honors by KING GEORGE VI. For many years preceding his semi-retirement a few months ago, Sir Andrew was one of the most active and hard-working executives to be found anywhere in the industry. He was a director in 69 companies of the Royal Dutch Shell group and his interest extended to every branch of the business. The great fleet of Shell tankers was built up under his supervision and he served as managing director of Anglo-Saxon Petroleum Company Ltd., the tanker operating corporation, until last year. At that time a desire to lighten his business burdens caused him to retire from that position in which he was succeeded by G. LEGH-JONES. At the present time Sir Andrew's attention is devoted mainly to the production side of his companies' operations.

THEODORE J. E. UMBECK, treasurer-comptroller of International Association (Petroleum Industry) Ltd., returned to London June 15th on board the MANHATTAN. He was accompanied by Mrs. Umbeck.

EDWARD M. CRONE, secretary of The Texas Corporation and of several of its affiliated companies, died June 20th at the age of 46 years from cerebral hemorrhage resulting from injuries received in a fall. He had recently returned from an inspection tour of the company's concession in Colombia. Mr. Crone, who had been with the company 23 years, was socially active both in business and private life—he was chairman of The Texas Company's Committee on Employee Benefits and the Budget Committee, as well as belonging to the Bonnie Briar Club of Westchester, the the Cloud Club of New York, and the Masonic Order.

Edward M. Crone

SHEIKH HAFIZ WAHBA, minister in London to SHEIKH IBN SA'UD, ruler of the independent state of Saudi Arabia, arrived at the Hotel Waldorf Astoria in New York June 29th. He had come from Los Angeles en route from Japan, where he represented Ibn Sa'ud at the opening of a new mosque in Tokyo. In an interview Sheikh Wahba, who speaks English, mentioned that both gold and oil have been discovered in the Saudian state, and that he was expecting to hear while he was in New York that California Arabian Standard Oil Company had brought in another producer. He added, "The money which we get from our oil and the products we can buy . . . will help us with our modernization work. We have a very poor land, and a large nomad population (about 4,000,000). Sheikh Ibn Sa'ud has devoted much of his time and energy to the work of settlement, and about a third of our Bedouin nomads are now settled, thanks largely to his work."

Dr. N. L. Anfilogoff, director of technical services of The Texas Corporation in Europe, who returned from New York on board the Ile de France June 22nd.

R. P. RESOR, treasurer of Standard Oil Company (New Jersey), will retire from business life on August 10th. He is now in his 50th year of service, having started as office boy in 1889. An informal party was held in his honor June 28th by officials and department heads of Jersey Standard, upon which occasion a gold watch and a leather-bound note book containing the signatures of all the members of his staff were presented to him. WM. S. FARISH, president, described his career as a "real job, uniquely and beautifully carried out." Mr. Resor replied that he had been "lucky" all his life. After his retirement he plans to "keep young and play."

Sheikh Hafiz Wahba as he sailed from New York on board the Queen Mary, July 6th.

P. F. SHANNON, manager for Tropical Oil Company at El Centro, Colombia, arrived in New York June 13th on board the SANTA ELENA. He was accompanied by his wife. Also on board were JOHN W. and MRS. MCNAMARA, en route from Barranquilla, Colombia. Mr. McNamara is sub-manager for Texas Oil Company at Bogota.

H. G. MANN, managing director of the well-known European business house of Phs. van Ommeren and Company, sailed from New York on board the liner STATENDAM June 3rd, with Mrs. Mann. His firm is an important independent owner and operator of tankships, and is understood to have been first to introduce modified streamlining to tanker superstructures.

JOHN S. MELLON, probably the most well-known man in the oil industry equipment business, died of heart failure in Los Angeles July 3rd. Originally sales manager for Dunn Manufacturing Company, he has been with Byron Jackson Company ever since it absorbed the former concern in 1929. Mr. Mellon had a wide acquaintance among oil men both in the United States and abroad, and his passing will be regretted by many.

MRS. M. F. LAMBERT, oil operator of Houston, sailed for Europe on board the PRESIDENT ROOSEVELT June 22nd. She was accompanied by her nephew and niece, JAMES L. WOOD and MISS PATRICIA C. WOOD.

JERSEY STANDARD'S 175 Million Dollar Improvement Program

SECOND largest offering of securities for industrial purposes on the New York market since the beginning of 1938 was the issue of $85,000,000 in serial notes and debentures put out by Standard Oil Company (New Jersey) early in July. The issue was remarkable also for the low interest rates which ranged from 1.75 to 2.75 percent according to maturity. The list of underwriters included sixty-two leading financial houses.

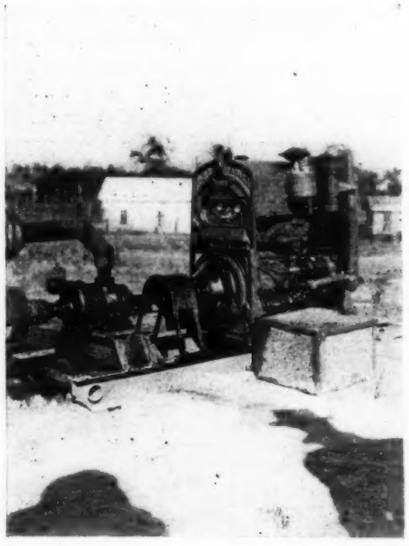
Proceeds of the issue are being placed in the general treasury of the company and will be used in making available to subsidiaries funds for capital expenditures and other corporate purposes. The tentative program includes estimates of about $90,000,000 for acquiring and developing crude reserves, $38,000,000 for extending and improving refining facilities, $15,000,000 for tankers, $24,000,000 for marketing facilities, and $8,000,000 for miscellaneous purposes.

HIGH PRESSURE ROTARY

ALTHOUGH old in principle the rotary pump has been a stepchild of the pump family for some time. Pump designers have neglected it for many duties on account of its obvious failure to meet conditions as successfully as its rivals, the centrifugal and reciprocating pumps.

The reciprocating pump has, so far, largely filled the field of high pressure pumping for high pressures with small or moderate volume, especially for viscous liquids. The centrifugal pump is supreme in the field of large volume, low pressure pumping of low-viscosity liquids. On the other hand, the rotary pump on which previous designers have expended only a small percentage of the serious thought and technical development bestowed on reciprocating and centrifugal pumps, has heretofore been restricted chiefly to small and moderate volume work at pressures not exceeding 250 to 300 lbs. To a limited extent it has been developed for pumping small volumes, at pressures up to 1000 lbs., but only with fair success.

The Guiberson Corporation has now taken this Cinderella of the pump family in hand and has placed it on at least an equal footing with its sisters. They have produced rotary pumps for pipeline service with considerably higher efficiencies than centrifugal pumps, and much higher than the rotary types previously in use. It is possible to operate these new rotary pumps against 300 to 1000 lbs. pressure and show overall efficiencies from 75 percent to 88 percent on oil of SUS 40 to 80 viscosity, and volumetric efficiencies



Guiberson high pressure rotary in the East Texas field where it has undergone rigorous tests.

from 75 percent to 95 percent; on more viscous crudes the volumetrics are still higher. Units now in operation handle 10 to 320 bbl. an hour with constant pressures to 600 lbs. and intermittent pressures to 800 lbs. Larger units under construction will produce up to 36,000 bbl. a day with 1000 lbs. as the maximum continuous operating pressure.

As stated above, this new type of rotary pump has the advantage of efficiency over centrifugal pumps and within the pressure limits so far covered is superior to the reciprocating pump, with the added advantage of fewer wearing parts, greatly reduced weight, size, and direct drive from the shaft of any prime mover without gears of any kind.

The Guiberson pipeline rotary pump is of the interval gear, one-tooth difference, positive displacement rotary type. The displacing action is obtained by the rotation of an eight-tooth pinion mounted on a shaft which is eccentric to the ring gear and pump casing. The pinion rotates within a nine-tooth ported ring gear and is revolved by the shaft. The ring gear turns on the pinion as an idler. Abutments or barriers are placed between suction and discharge ports, thus providing the necessary suction effects. Long life and low maintenance are assured by the use of hardened steel, which is durable and corrosion-resisting.

Alcohol Mixture Becomes Compulsory in Japan

WITH the object of economizing the consumption of gasoline under the China Incident, the Japanese Government has compelled the mixture of absolute alcohol with gasoline in Japan proper and Formosa as from July 1, 1938. The compulsory alcohol mixture is according to the provisions of the Gasoline and Alcohol Mixture Law promulgated late in 1937. According to the present schedule, the Government plans to have a mixture of five percent of alcohol with one-quarter of the total volume of gasoline imported by the importers and also with one-quarter of the total volume of gasoline manufactured by domestic refiners. The extent of gasoline subjected to the alcohol mixture and the alcohol mixture percentage will be advanced as the domestic production of alcohol increases until all descriptions of gasoline consumed in the Empire may be subjected to twenty percent alcoholic mixture.

PORTABLE RIG

A PORTABLE rig with three compounded Caterpillar Diesel engines developing 375 h.p. has been evolved by the Unit Rig and Equipment Co., and was exhibited at the recent Petroleum Exposition at Tulsa. All three engines are synchronated to work together or separately in a large range of combinations. It is said that this is the first high-speed apparatus to use three engines compounded. The rig has sufficient capacity for drilling operations to depths of 6,000 ft. and can be moved about on one truck. A special feature of this rig is an automatic cathead designed with only two working parts, rotor and jerkline.

Kig capable of 6000 ft. with three engines compounded and mounted on a single truck.

WORLD OIL PRODUCTION—Official Figures

All figures furnished direct to WORLD PETROLEUM by governments, except where otherwise specified—Table revised monthly

(Figures in U.S. barrels of 42 gal.—Conversion ratios used are weighted averages for individual countries)

	June 1937	July 1937	August 1937	September 1937	October 1937	November 1937	December 1937	January 1938	February 1938	March 1938	April 1938	Preliminary Figures May 1938
United States	105,812,000	110,721,000	115,090,000	109,980,000	110,911,000	104,206,000	106,579,000	106,007,000	94,662,000	106,524,000	102,702,000	99,834,000
Russia[2]	17,953,812	18,580,752	17,183,259	16,663,000[1]	17,600,000[1]	16,923,000[1]	17,600,000[1]	17,647,000[1]	13,591,000[1]	15,984,000[1]	17,850,000	17,580,000
Venezuela	16,260,492	16,469,071	17,861,784	17,640,872	17,979,227	17,044,016	17,096,298	15,271,901	13,792,479	15,109,040	13,696,219	15,994,400
Iran[3]	6,752,478	7,213,398	7,313,264	7,198,034	7,075,122	6,821,616	5,999,642	5,907,458	6,414,470	8,284,215	7,090,486	7,000,000
Netherland India	4,464,725	4,708,460	4,672,953	4,586,638	4,766,689	4,626,395	4,671,582	4,245,587	4,235,422	4,721,147	4,568,899	4,764,193
Roumania	4,151,000	4,317,000	4,293,000	4,256,000	4,313,000	4,162,000	4,198,000	4,099,000	3,751,692	4,182,000	4,090,000	4,169,000
Mexico	3,338,311	3,848,587	2,800,868	3,432,101	4,372,808	4,211,293	4,349,415	4,141,977	4,017,000†	900,000†	700,000†	1,700,000‡
Iraq	2,344,213	2,429,587	2,429,787	2,513,145	2,663,244	2,645,099	2,431,532	2,670,844	2,385,464	2,717,278	2,592,996	2,332,746
Colombia	1,724,173	1,681,799	1,592,592	1,617,433	1,811,759	1,797,625	1,824,956	1,784,638	1,508,487	1,841,882	1,616,684	1,804,111
Peru[4]	1,432,398	1,488,965	1,494,467	1,453,712	1,492,971	1,432,508	1,481,701	1,365,152	1,340,000[1]	1,474,364	1,296,090	1,343,259
Argentina	1,339,940	1,355,420	1,345,513	1,369,767	1,360,000[1]	1,365,000[1]	1,370,000[1]	1,378,000[1]	1,289,000[1]	1,380,000[1]	1,349,000[1]	1,382,000
Trinidad	928,752	1,377,547	1,433,474	1,358,600	1,393,317	1,300,485	1,349,908	1,378,021	1,304,819	1,438,436	1,418,825	1,481,285
Burma[5]	638,874	633,401	679,335	701,066	704,736	631,584	640,195	662,000[1]	598,000[1]	650,000[1]	637,000[1]	652,000
Bahrein[6]	684,348	585,917	254,937	662,861	847,988	749,354	805,236	805,800	707,379	737,164	692,403	620,746
Brunei[7]	349,500	353,313	373,760	341,111	351,711	376,487	405,623	409,592	381,052	445,194	428,829	445,505
Poland	310,780	318,360	318,360	310,780	325,940	318,360	325,940	318,928	293,232	327,077	318,000[1]	319,000
Germany	249,434	267,847	279,727	282,155	288,926	272,665	277,551	268,028	257,967	355,683	342,387	329,688
Canada[8]	209,181	241,737	288,934	298,753	342,452	341,517	408,580	457,408	413,158	480,803	464,316	472,000
Japan[9]	200,092	204,710	214,819	205,914	210,228	214,330	211,436	218,594	214,191	214,820	207,522	217,000
Ecuador	182,696	186,175	184,780	178,122	182,053	176,252	178,776	187,525	171,138	191,746	181,331	190,542
British India[10]	181,436	183,468	182,311	173,150	181,089	197,043	210,360	195,000[1]	167,000[1]	200,000[1]	187,000[1]	193,000
Sarawak[11]	131,625	143,445	138,031	134,311	133,684	126,439	131,901	137,497	126,578	137,281	133,248	137,824
Egypt[12]	98,021	99,182	97,818	100,699	97,203	95,082	94,509	91,927	84,974	94,545	88,555	89,935
France	45,445	42,125	43,367	44,000[1]	42,339	42,639	42,368	43,000[1]	38,000[1]	43,589	42,839	42,000
Austria	18,410	18,890	13,860	17,010	18,620	20,850	19,320	25,620	28,160	30,070	29,100	41,600
Czechoslovakia	10,824	11,529	10,125	9,667	10,865	12,297	11,734	11,070	10,437	12,158	10,731	11,000
Bolivia	10,692	12,148	13,509	12,271	10,736	11,751	12,810	10,302	7,128	9,100[1]	8,800[1]	9,000
Others[1]	17,600	17,100	15,700	16,000	18,500	17,600	16,400	18,900	19,300	18,800	16,500	20,000
Totals	169,841,252	177,510,933	180,620,334	175,557,172	179,506,243	172,039,287	172,644,773	169,757,769	151,809,527	168,504,392	162,759,760	163,155,834

[1] Estimate. [2] Russian Sakhalin included with Russia.
[3] Anglo-Iranian Oil Company Ltd figures revised—fuel oil returned to ground has been deducted.
[4] International Petroleum Company and Lobitos Oilfields Ltd. figures combined.
[5] Does not include Assam and Punjab, which are listed separately under British India.
[6] Bahrein Petroleum Company Ltd. figures.
[7] British Malayan Petroleum Company Ltd. figures.
[8] Includes natural gasoline production.
[9] Japanese Sakhalin, Taiwan (Formosa) and Hokkaido included with Japan.
[10] Excluding Burma.
[11] Sarawak Oilfields Ltd. figures.
[12] Anglo-Egyptian Oilfields Ltd. figures.

† Estimated by competent private sources in Mexico.
‡ Estimate based on information supplied by the C.T.M. (labor syndicate).

Official Crude Oil Production Figures for 1932 to 1937 (Revised)

	Daily Average to May 3 1938 (Bbl.)	Daily Average 1937 (Bbl.)	Total to May 31 1938 (Bbl.)	Total 1937 (Bbl.)	Total 1936 (Bbl.)	Total 1935 (Bbl.)	Total 1934 (Bbl.)	Total 1933 (Bbl.)	Total 1932 (Bbl.)
United States	3,375,689	3,500,418	509,729,000	1,277,653,000	1,098,516,000	996,596,000	908,065,000	905,656,000	785,159,000
Russia	534,119	553,305	80,652,000	201,856,661	199,635,921	184,008,033	175,635,783	155,596,429	155,927,997
Venezuela*	489,172	514,182	73,864,039	187,675,477	155,270,840	148,809,057	136,098,681	117,113,940	115,615,782
Iran*	228,454	213,997	34,696,629	78,109,001	62,977,950	57,520,488	57,902,092	54,440,075	49,516,697
Netherland India	149,240	148,255	22,535,248	54,112,933	47,961,744	45,307,913	45,107,828	41,234,498	37,988,913
Roumania	134,382	142,948	20,291,692	52,176,000	63,532,846	61,270,072	61,849,306	53,919,708	53,651,978
Mexico	75,887	127,275	11,458,977	46,455,687	41,027,915	40,240,563	38,171,946	34,000,830	32,805,496
Iraq	84,101	83,846	12,699,328	30,603,660	29,913,150	27,410,983	7,639,849	1,094,915	871,840
Colombia	56,661	55,609	8,555,802	20,297,543	18,756,110	17,597,655	17,337,900	13,156,126	16,415,214
Peru*	45,158	47,827	6,818,865	17,457,024	17,593,059	17,066,555	16,314,381	13,257,318	9,899,432
Argentina*	44,887	44,807	6,778,000	16,354,717	15,457,960	14,297,025	14,021,901	13,690,556	13,138,747
Trinidad*	53,122	42,473	8,021,386	15,502,989	13,237,030	11,671,224	10,894,363	9,561,353	10,126,121
Burma	21,185	21,279	3,199,000	7,766,487	7,587,718	7,181,113	7,278,859	7,114,311	7,073,437
Bahrein*	23,599	21,266	3,563,492	7,762,264	4,644,635	1,264,807	285,072	31,377	902
Brunei*	13,975	12,047	2,110,172	4,397,038	3,355,086	3,359,054	2,741,341	2,070,162	1,220,486
Poland*	9,776	10,416	1,476,237	3,799,862	3,869,575	3,901,881	4,011,336	4,174,079	4,219,634
Germany	10,289	8,625	1,553,753	3,148,300	3,076,858	2,967,438	2,204,402	1,656,602	1,594,807
Canada*	15,150	8,026	2,287,685	2,995,025	1,507,931	1,447,204	1,410,895	1,145,333	1,044,412
Japan	7,100	6,817	1,072,127	2,487,841	2,403,072	2,294,878	1,872,837	1,304,412	1,683,439
Ecuador*	6,108	5,922	922,282	2,161,436	1,942,467	1,731,785	1,636,619	1,619,902	1,597,641
British India	6,238	5,864	942,000	2,141,158	1,978,329	2,037,810	1,921,863	1,628,803	1,743,878
Sarawak*	4,453	4,535	672,428	1,655,565	1,574,196	1,806,795	1,975,617	2,244,331	2,369,338
Egypt*	2,980	3,187	449,936	1,163,267	1,262,666	1,255,151	1,527,252	1,653,535	1,071,976
France	1,387	1,387	209,428	507,067	534,063	529,664	700,000	786,366	755,146
Austria*‡	1,026	606	154,550	221,266	50,092	44,347	27,965	5,765	804
Czechoslovakia*	367	339	55,396	123,474	126,603	136,580	177,797	121,695	126,603
Bolivia*	293	337	44,330	123,123	104,746	163,295	157,875	111,973	41,907
Other countries	619	606	93,500	221,000	198,600	189,200	243,100	273,500	327,900
Total	5,395,417	5,586,201	814,907,282	2,038,928,865	1,798,087,162	1,652,106,570	1,517,211,860	1,438,864,897	1,305,588,467

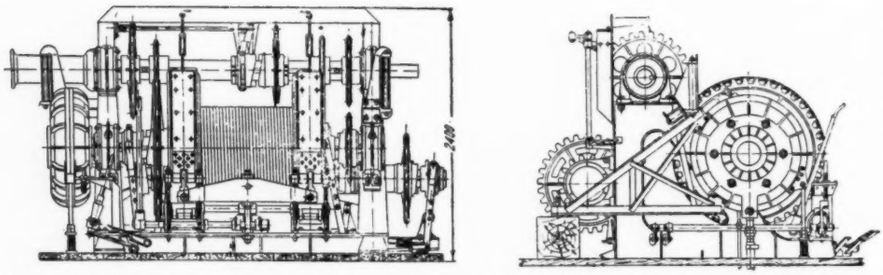
*Revised by official sources.
‡Conversion factor revised.

U. S. S. R.

Official Figures for Soviet Oil Operations

	Monthly Production (Bbl.)	Daily Average (Bbl.)	Run to Stills (Bbl.)	Drilling (Ft.)
January, 1938	17,647,000	569,258	15,882,000	520,000
February	13,591,000	485,393	13,122,000	320,000
March	15,984,000	515,613	14,842,000	340,000
April	17,850,000	595,000	15,850,000	400,000
May	17,580,000	567.097	15,600,000	420,000
Jan.-May, 1938	82,652,000	547,364	75,296,000	2,000,000
Jan.-May, 1937	80,352,838	532,138	72,842,853	2,477,037
Total, 1937	202,856,661	555,772	187,121,389	6,244,660
Total, 1936	199,634,921	545,450	180,582,274	6,958,916
Quota, 1938	244,215,000*	666,066	215,055,000	not available
Quota, 1937	234,450,000	642,329	208,285,000	9,240,000
Quota, 1936	222,345,000	607,000	182,250,000	7,100,000

*Crude oil and gas.

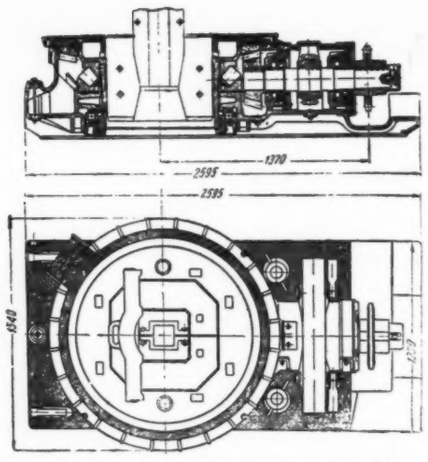


Four speed drum hoists with a capacity of 17 tons on drums and static load on hook of 150 tons.

OPERATIONS

IMPROVEMENT of Soviet oil operations effected in April continued in May, and Baku fields came close to plan fulfillment for the 31 day period, while they exceeded plan by one or two percent on individual days. Of the 63 Baku oilfields, about 40 have lived up to plan during May, while the other 23 fields continued to lag behind schedule. Taken by the groups into which they are divided, Stalin, Artema, Asisbekov, Kergez and Molotov lived up to the production quota during April and have continued with some excess over the plan during May, while Kirov, Ordzonikidze, Kaganovitch, Lenin, Aliati and Grozneft operated behind requirements during the month and caused production arrears of about 5,000 bbl. of crude daily.

Grozni has shown signs of improvement for the first time in many years, and is consistently living up to plan. Next in importance, Maikop has developed a number of properties which have enabled it to maintain production steadily in excess of plan—20 to 33 percent—and has a daily output of 43,000 to 45,000 bbl. against less than half that amount in 1937. Maikop crude is of light grade and has a higher gasoline content than any other Soviet crude oil, as well as having considerable content of natural gas suitable for stripping casinghead gasoline. Operations at Emba during May were likewise in a favorable position, the high and low of the month being 108 and 90 percent of quota. Emba fields are capable of doing even better as the potentialities of the region are great. Bashkiria produced quite close to plan during the first quarter of 1938, but fell off a little during April and May.



Closed type rotary table for depths to 10,000 ft.

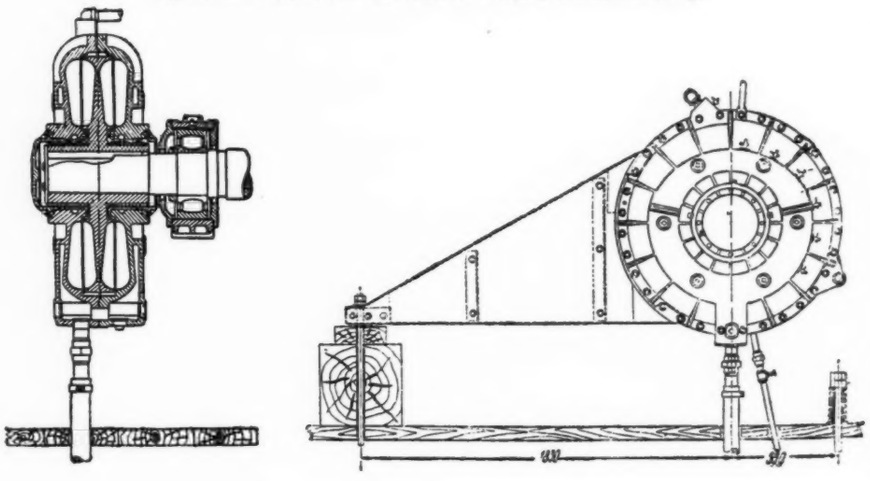
EQUIPMENT

SEVERAL years ago the Soviets ceased to import oil well drilling equipment from abroad, since which time the domestic machine shops have been striving to modernize and perfect the equipment available. The Lieut. Shmidt machine shops of Baku are reported to have perfected in design and construction several types of drilling and production equipment. They have evidently adopted the types of equipment previously imported, that is, copied the designs and adjusted them to suit Soviet requirements. After having tried the new equipment in operation the Russians believe the domestic types to be not inferior to their equivalents which were formerly imported. Except for the fact that the American design and fabrication have made tremendous strides during the past few years and providing the workmanship is good there is no reason why they should be inferior—the American designs which they copied are good.

Lieut. Shmidt machine shops have evolved a new design of four-speed drum hoist

(Continued on page 116)

Hydromatic brake GTI 915 used in modern Russian drilling.



WORLD PETROLEUM ABSTRACTS

Summaries of the Most Important Articles as Published in the Oil Press of the World Dealing With Technical and Economic Aspects of the Petroleum Industry. Edited by Dr. O. W. Willcox

DRILLING

Intensive Weighting of Petroleum Drilling Muds With Galena—H. E. Gross, in PETROLEUM TECHNOLOGY, vol. 1 (1938), No. 2. Technical Publication No. 918; 9 pages.

There are special conditions in excessively high-pressure wells that warrant the use of heavier and thinner muds to relieve pressures on blow-out-prevention equipment. Most instances that would justify these intensively weighted drilling fluids have narrow mud-weight tolerances above which the mud is dissipated into lower pressure formations and below which it is gas-cut or upset by salt-water intrusion. However, there are several cases on record of 17 lb. or more per gallon mud being used to control deep wells. Viscosity reduction for such a fluid is an important item and could be accomplished by the use of galena. Pure galena muds have good wall-buildings characteristics, and this soft, friable mineral is not abrasive to pump parts. The acid nature of galena muds can be corrected by buffering. Galena is an abundant heavy mineral but its high cost will prevent indiscriminate use, although there are conditions in which it can give a specially needed service.

This paper gives details of laboratory studies on the subject, carried out at the University of Oklahoma.

Recent Pressure Drilling at Dominguez (Calif.)—S. Grinsfelder and Jan Law in OIL WORLD, vol. 31 (1938), No. 9, pp. 14-19.

In the latter part of 1937 four wells were completed in the Dominguez field to test the theory that if wells are completed in the pay zone under a pressure less than the formation pressure the well will be more productive than if the walls of the hole are subjected to the full pressure of the usual column of mud. In the latter condition the higher pressure tends to force the mud into the pores of the pay sand, thus making it more difficult for the oil to flow out. On the other hand, if a mixture of oil and gas that generates a bottom hole pressure lower than that of the formation pressure is used as the completing fluid, the outwardly prevailing formation pressure will keep the sand face open.

In practice, the establishment of a bottom hole pressure less than the static pressure of the formation requires a careful appraisal of the circumstances. The static formation pressure will be given by subsurface data compiled periodically for the field. On the other hand, the estimation of a general bottom-hole pressure involves the consideration of several factors: rate of oil circulation, rate of gas circulation, depth of hole, size of effective flow channels and input and output pressures.

A method for calculating a bottom-hole pressure to be generated was derived by E. C. Babson. This method, though not wholly satisfactory, provided an approach to the problem. The calculations take into consideration the depth, composition and input pressure of the column of fluid within the drill pipe. The equation $Ddh = dP$ is integrated in terms of $h = VdP$ from material made available by A. P. I. research problem No. 37. In this equation,

h = height of column
P = pressure
D = density
V = specific volume

These calculations do not take into consideration friction losses and slippage which may be of considerable magnitude. The application of this method, though not thoroughly satisfactory, demonstrated that it provided a working basis for estimating generated pressures at the bit.

It appears that the maximum benefits to be derived are especially from wells which have highly permeable sands, and from producing intervals that have been somewhat depleted.

Casing Setting Depths are not Assured by Physical Properties of the Steel—W. W. Frame, before AMERICAN PETROLEUM INSTITUTE, Wichita meeting, May, 1938.

The results of nearly 400 collapse tests of oil country casing are described in the paper. Parts of these tests were made with various amounts of residual stresses existing in the pipe structure. The results show that unfavorable residual stresses of a magnitude not uncommon in casing can reduce the collapse pressure 15 percent or more, depending on the $\frac{D}{t}$ ratio involved.

The results of nearly 300 collapse tests of pipe practically free of residual stresses show that collapse pressures can be obtained that were previously considered impossible except with steel of much higher yield strength.

With reference to the method of testing, it was found that closed-end specimens collapsed at higher pressures than open-end specimens cut from the same piece of pipe. It is concluded that the specifications for yield strength of the steel are inadequate for assuring setting depths in collapse, and that the method of manufacture and the method of testing must also be considered.

In view of these facts and conclusions, it would seem desirable that certain additions and changes be made to casing specifications. It would be helpful, and avoid confusion, if a standard test specimen and standard test procedure for determining collapse values of oil-country casing could be adopted by the A. P. I. And it seems desirable that the Institute should define the various casing grades by specification of setting depth in collapse, without reference to any specification of physical properties of the steel other than ductility.

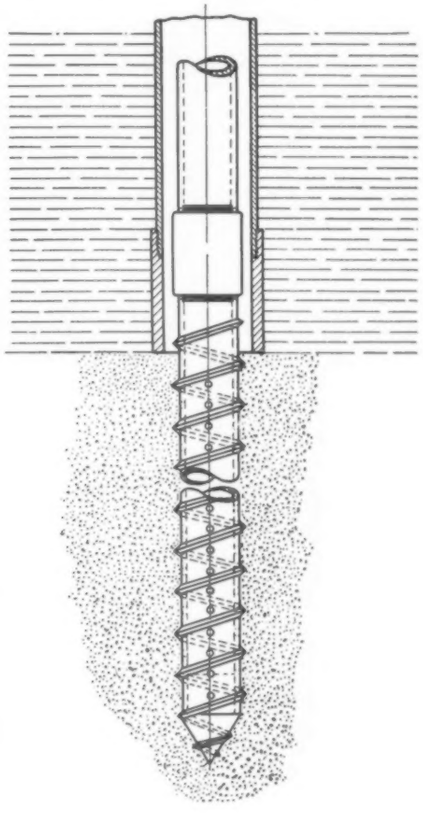
OPERATION

Experiments on Fluid Capacity and Plugging of Oil-Well Screens—R. L. Chenault, before AMERICAN PETROLEUM INSTITUTE, Wichita meeting, May, 1938.

A number of tests were made on samples of various types and makes of oil-well screens to determine free-flow characteristics, flow characteristics when packed in sand, conditions under which screens are likely to plug, and precautions necessary to prevent plugging.

It was found that there is little relation between free-flow characteristics and flow characteristics when packed in sand. In general, the pressure drop through a sand-pack of any considerable thickness is so much greater than the drop through an open screen that variations of several hundred percent above or below the average resistance of commercial screens to free flow are of little significance in predicting the fluid capacity of a screen and sand-pack under operating conditions.

Screens of the wire-wrapped, slotted-pipe, and button types were tested; and in all cases the screening action was practically perfect—although in some cases about 60 percent of the sand was small enough to pass through the screen openings. When circulating clean oil through a sand-pack and screen



at a constant pressure, the rate of flow reached an equilibrium value, when the oil temperature and viscosity became constant, and remained at this value indefinitely—indicating that permanent sand bridges were formed almost immediately after starting flow.

Several attempts were made to plug a screen and sand-pack with drilling mud by placing layers of mud in various positions in the sand-pack, and by injecting mud into the oil inlet to the screen-testing chamber. It was found that the mud would not migrate more than one-quarter inch through the sand-pack before it was entirely filtered out by the sand. Surrounding the screen pipe with a porous filtering medium such as sand or gravel, which will fill the well cavity and prevent caving of the formation, and migration of mud or other colloidal material to the screen face, appears to be the most logical solution of the problem of screen plugging and sand production.

References are made to methods now being used for placing gravel or sand-packs, and some new methods are suggested, including the one illustrated in the accompanying figure.

In this case the liner would be equipped with a coarse and rugged outside thread, as shown. The well cavity would be filled by means of a bailer or by dropping the packing material through the casing. The liner would be run on tubing and rotated, after contacting the sand or gravel bed, in a direction tending to pull the liner into the pack and loosen the material immediately surrounding the liner, and displace a sufficient quantity of it into the casing by the screw-conveyor action to allow the liner to lower to the desired position.

Drilling and Production in the Wilmington (Calif.) Field—C. J. Dean, in OIL WORLD, vol. 31 (1938), No. 9, pp. 3-11.

The problems encountered and methods used in this field are discussed at some length.

The chief problem is the control of sand production, and the conclusion is reached that, fundamentally, the matter lies in regulation of the velocity of fluid entry into the casing, i. e., to reduce the rate of flow of gas and oil to a point where the sand will not be removed. The following methods for this purpose have been used in this field:

First, the use of a smaller bean. Second, flowing the well from the casing to reduce the surge chamber. Third, the use of a packer on the tubing to eliminate the surge chamber. Fourth, the bleeding of casing to a pressure insufficient to blow around the tubing. Fifth, the use of gas lift to stabilize the flow in the tubing. Sixth, the use of a spring actuated valve or bean to close at a set minimum tubing pressure. If heading flow cannot be satisfactorily controlled, it is good practice to put the well on the pump.

The results of gravel packing to date indicate that this process will be a major factor in the solution of the sand problem.

Theoretical Consideration of the Perforation Pattern in a Screen Pipe—J. M. Cunningham, before AMERICAN PETROLEUM INSTITUTE, Wichita meeting, May, 1938.

The possible size, shape, and arrangement of the perforations in a screen pipe are innumerable. For a given perforation area, the size, shape, and arrangement of the perforations will greatly influence the strength of the screen. Within limits, the size of the perforation has not much influence on the strength when the perforations are uniformly distributed. Experience indicates that the size of the perforation is more important in preventing clogging of the screen. An approximate strength rating is given for the common-shaped perforation patterns.

It is not economically possible to design screen pipe to resist large-scale movement or shifting of the earth formations. The strength design should consider resistance to bending, longitudinal tension, longitudinal compression and, if necessary, transverse compression.

High columnar strength considers high bending and high longitudinal-compression strength. It also considers longitudinal tension indirectly. Thus, columnar strength represents a basis for selecting the perforation pattern.

The optimum perforation pattern with reference to columnar strength is one which has the perforations uniformly distributed both longitudinally and circumferentially, and has a combination consisting of a few perforations per row around the pipe and a larger number of rows of perforations per unit length.

Sharp corners in perforations are to be avoided in order to minimize stress concentration. The large reduction in columnar strength for any increase in the unsupported screen length recommends the advisability of providing complete support along the entire length of the pipe wherever possible.

A perforation pattern selected for high resistance to tubular collapse will have an arrangement which will give the maximum moment of inertia per unit length of the minimum longitudinal wall section.

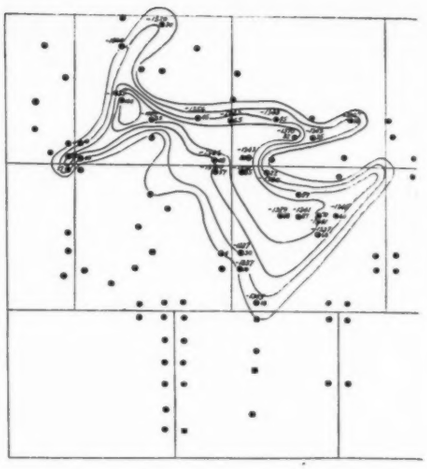
While it is known that the pressure drop through the screen perforation is only a small part of the total pressure drop restricting the oil flow from the formation, nevertheless greater perforation area provides greater probable number of flow orifices and, in effect, increases production and the period between work-over and clean-out.

NATURAL GAS

Gas Caps, Their Determination and Significance—P. P. Gregory, in PETROLEUM TECHNOLOGY, vol. 1 (1938), No. 2. Technical Publication No. 917; 5 pages.

Natural petroleum gas occurring in the oil-bearing reservoirs is found to exist either as free gas associated with the oil and/or in solution in the oil. In some virgin fields practically no free gas is encountered under the reservoir conditions of pressure and temperature, although in other fields a considerable section of the pay horizon is occupied by free gas. In other words, a given oilfield may or may not have a gas cap before the exploitation takes place. When the reservoir pressure is reduced to a point below the critical saturation pressure by withdrawals of fluids from the producing formation, the gas dissolved in the oil inevitably begins to come out of solution and becomes free gas. Under the controlled methods of production and drilling, a portion of this gas is produced with the oil to the surface and a portion of it remains within the reservoir to accumulate at higher structural levels toward which it migrates by virtue of its low specific gravity. The rate of growth of a gas cap in a given structure depends primarily upon the rate of decline in the reservoir pressure. If the rate of pressure decline is rapid, the gas cap likewise will grow rapidly. On the other hand, shrinkage in the gas-cap area was noted in some fields in which reservoir pressures were increasing.

The gas-oil contact can be conveniently located in the process of drilling a well and by electrical logging. Little can be found in the petroleum literature concerning methods of predetermining gas-oil contacts in producing reservoirs. Therefore, the writer feels justified in describing briefly a simple, workable, and inexpensive method of determining gas-oil contacts and outlining the limits of gas-cap areas in a field where such knowledge may be essential for efficient production and development operations.



The method involves the determination of the following: (1) Structural data, such as the depth or elevation of the top of pay horizon; (2) reservoir pressures; (3) tubing and casing pressures at the well head; (4) static oil-pressure gradient; (5) static gas-pressure gradient. These data can be secured with a minimum of expense and may be shown in the form of a map (as in the accompanying sketch) where the contours indicate thickness of the gas cap (contour interval 25 ft.).

Behavior of Contents of High-Pressure Reservoirs—Eugene A. Stephenson, in PETROLEUM TECHNOLOGY, vol. 1 (1938) No. 2, Technical Publication No. 916; 9 pages.

In most instances the fluids produced from underground reservoirs have been described as they appear at the surface, and usually it has not been necessary to distinguish between surface and reservoir phases. More recently it has become imperative to recognize the fact that changes in phase may occur between the reservoir and the receiving unit.

The simple terminology of wet and dry gases and crude petroleum oil served our needs fairly well in the shallow, low-temperature and low-pressure fields. It has been left to the legislatures, regulatory commissions, and courts to decide whether a field is or was a gas field, an oil-field, or both. This they have done by direct definition and also by implication. For example, in Texas.

A gas well is any well (a) which produces natural gas not associated or blended with crude petroleum oil at the time of production, or (b) which produces more than 100,000 cu. ft. of natural gas to each barrel of crude petroleum oil from the same producing horizon, or (c) which produces natural gas from a formation or producing horizon productive of gas only encountered in a well bore through which crude petroleum oil is also produced through the inside of another string of casing.

An oil well is any well which produces one barrel or more of crude petroleum oil to each 100,000 cu. ft. of natural gas.

In the state of Louisiana, the same general result is achieved largely by the following paragraph:

Wells producing both oil and gas shall not waste or blow into the air an amount of gas of more value at three cents per 1,000 cu. ft., than the market value of the oil recovered. The Commissioner of Conservation shall allow a reasonable time to determine the status of any well.

The author gives typical cases of where the question of whether a well was to be classed as an oil well or a gas well has been of great importance to

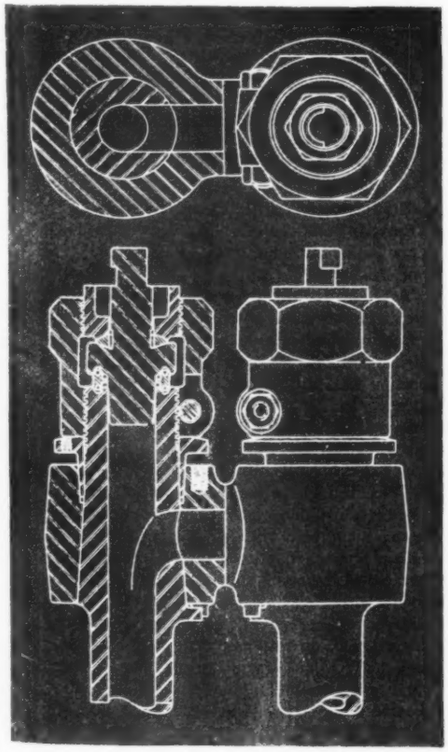
both owners and to state authorities. The general result is that the courts have adopted the rule that production of condensate (natural gasoline) from a wet gas does not make an oil well out of a gas well; in other words, a condensate is not crude petroleum oil.

REFINING

Necessity for Better Construction of Heating Coils—Fred Key and W. H. Clendenin, before AMERICAN PETROLEUM INSTITUTE, Wichita meeting, May, 1938.

The significant feature of this paper is the conclusion that, regarding the construction of heating coils, for the use of processing oils and other fluid matter, there is a definite necessity that the tube-connecting devices be attached to the tube in such a manner that there is no question about the connections being stable under pressure and temperature, and with a high factor of safety.

To clarify the problem under discussion, the words "tube-connecting device" refer to what is commonly termed a return-bend fitting used in constructing a coil consisting of a number of tubes in parallel relation to each other. The tubes are attached by expanding into an especially-prepared hole of the tube-connecting device, thereby creating a continuous coil for use in processing oils and other fluid matter.



Cross section of type "A" return bend designed for use with carbon-steel tubes or four to six percent chrome tubes.

After giving an exposition, with illustrations, of bad practice, the authors settle on five tube-connecting devices which meet the pressure and temperature conditions. One of these connections, on a type A return bend for use with carbon-steel tubes or four to six percent chrome tubes, is shown in the accompanying figure.

Removal of Inorganic Salts from Crude Petroleum—Wendell P. Hawthorne and H. L. Bedell, before AMERICAN PETROLEUM INSTITUTE, Wichita meeting, May, 1938.

De-salting systems in use in several Mid-Continent refineries are described.

Satisfactory salt removal may be accomplished by repeatedly washing oil through a sodium-carbonate solution of 200 deg. F. during 20 min. and settling at this temperature for 80 min. Less than three percent of 0.3 percent sodium-carbonate solution need be added continuously.

A system of treatment involving emulsification of three percent of 0.3 percent sodium-carbonate solution, percolation of the mixture through an excelsior column at 250 deg. F. during 20 min., and settling at 250 deg. F. for 50 min. results in the removal of 80 percent of the salt present in crude oil.

A comparison of results obtained in the laboratory with those obtained in plant operation indicates that results from a laboratory study should be approximately duplicated in the plant.

Application of the most satisfactory laboratory treatment in the refinery involves use of a 290 bbl. container as a packed column and of a 350 bbl. drum as a settler for each unit processing 10,000 bbl. a day; 13,000 gal. of water and 320 lb. of soda ash are required each day for each unit.

A mineral bed (14- to 20-mesh) is less effective than a corresponding excelsior bed for resolving a crude-oil emulsion.

CHEMISTRY

Determination of Sulphur in Oil—Robert I. Sheen and H. Lewis Kahler, in IND. ENG. CHEM., Analyt. ed., vol. 10 (1938), No. 4, pp. 206-207.

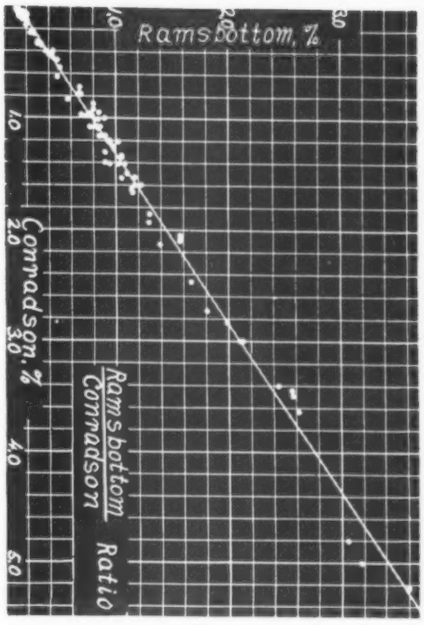
Sulphur in oil is usually determined by the barium sulphate precipitation method as prescribed by the American Society for Testing Materials. Analytical chemists have long sought a substitute to allow savings in time, and the investigators feel that the method presented here fulfills this requirement.

In this method sulphur in oil can be determined following the usual oxidation of an oil sample in a bomb, by direct titration using tetrahydroxyquinone as an internal indicator. Results obtained are well within the limits as prescribed by the A. S. T. M. and maintained by most oil companies; and the method is suggested for routine determination of sulphur in oil to effect a saving in time without sacrifice of accuracy.

The range of error is less than half that prescribed by A.S.T.M. for different operators and in all cases less than the variance allowed for the same operator.

Estimating Carbon Residue on Lubricating Oils—Charles I. Kelly, in PETROLEUM TIMES, vol. 39 (1938), No. 1003, pp. 429-431.

For estimating carbon residues in lubricating oils most American oil chemists use the Conradson method, whereas British chemists mostly prefer the Ramsbottom method. The author states that in laboratories where the two methods have been extensively compared preference is given to the Ramsbottom procedure, because it can be relied on to give concordant results within a comparatively small experimental error. The chief objection to the Conradson method is that it is not easy to perform accurately, in spite of all attempts to write directions that will permit of only one interpretation. It is prescribed that "tests shall be run in duplicate and repeated if necessary until the percentages of carbon residue differ by not more than 10 percent from an



average," which indicates the limitations of the method from a practical standpoint. A Conradson test can be made in 30 minutes, but it appears that only a specialist in this one test can be depended on to obtain results that are consistent and comparative.

The Ramsbottom method requires a more elaborate equipment, but allows of several determinations to be made concurrently under the same conditions, hence it is more dependable in making comparisons.

In view of the widespread use of both methods it has seemed desirable to demonstrate any fixed relation that may exist between them. This the author has done in a research that has embraced 92 lubricating oils and mixtures of oils from the United States, South America, Russia, and Roumania, comprising various grades, such as Pennsylvanian long residuums, bright stocks, dark lubricating oils, distillate lubricating oils, and solvent-refined oils produced by different processes.

The relationship between these results is depicted by the straight line in the accompanying graph, which may be expressed by the following equations:—

A.—To calculate the Conradson Carbon Residue (C.C.R.) when the Ramsbottom Carbon Residue (R.C.R.) is known:—

$$C.C.R. = 1.515\ (R.C.R. - 0.12)$$

where R.C.R. $>$ 0.2 percent.

B.—Conversely:—

$$R.C.R. = 0.12 + (C.C.R. \times 0.66)$$

where C.C.R. $>$ 0.12 percent.

Where the R.C.R. is less than 0.2 percent, and the C.C.R. is below 0.12 percent., a relationship is not so clearly demarcated, but the following appear to be reasonable approximations:—

C. $C.C.R. = 0.7\ (R.C.R. - 0.03)$

where R.C.R. $<$ 0.2 percent.

D. $R.C.R. = 0.03 + (C.C.R. \times 1.45)$

where C.C.R. $<$ 0.12 percent.

Catalysts in Hydrocarbon Chemistry—E. K. Rideal, in JOURNAL INSTITUTION PETROLEUM TECHNOLOGISTS, vol. 24 (1938), No. 174, pp. 221-225.

In hydrocarbon chemistry increasing attention is being paid to catalytic processes. It is shown that these can be formulated on a radical mechanism. Homogeneous reactions can be brought about by

free radicals and heterogeneous reactions by chemi-adsorbed radicals. The energy of activation of such heterogeneous processes is less than one-fourth of the corresponding homogeneous reactions. This permits of lower temperature operation, greater efficiency and greater control.

It is usually considered that in reactions where a metal catalyst is used to effect hydrogenation the metal simply functions to absorb molecular hydrogen and then gives it up again in an activated or ionized form. It is more probable that the reaction proceeds through some sort of exchange reaction between atoms held by chemi-adsorption and atoms in molecules held above this layer by weaker fields. This concept of exchange reactions, being one of the important mechanisms in heterogeneous catalytic reactions, can be revealed in another way. If ethylene and deuterium be passed over a nickel contact surface, not only is dideuteroethane formed, but at the same time some of the hydrogen atoms in the ethylene exchange with those in the deuterium producing H_2 and HD in the deuterium fraction coming from the catalyst. In addition to the olefines, a number of such exchange reactions have subsequently been discovered and examined; thus Taylor found that the saturated hydrocarbons would undergo exchange with deuterium. Whilst the reaction may be formulated

$$CH_4 + D_2 \rightleftarrows CH_3D + HD$$

the kinetic mechanism cannot proceed in this way. It is found that the reaction rate is much less than the ortho-para deuterium reaction, consequently the rate-determining step may be either

$$MD + CH_4M = CH_3DM + MH \quad .. \quad .. \quad (1)$$

or

$$CH_4M \rightarrow CH_3M + MH \quad .. \quad .. \quad .. \quad (2)$$

followed by the rate-determining reaction

$$CH_3M + MD \rightarrow CH_3DM + M$$

Since these reactions are taking place in the adsorbed phase, it is clear that it is impossible to decide between (1) and (2) by kinetic measurements. The simplest method of attack is to pass mixtures of CH_4 and CD_4 over the contact agent; if the mechanism of exchange is represented by (2) we should obtain mixed methanes—i.e., CH_3D, CH_2D_2, CHD_3. Experiment actually confirmed this view. In the same way the mechanism of the surface reactions involving the synthesis of ethane from methane and methane from ethane and hydrogen—

$$M.CH_4 \rightarrow M.CH_3 + MH \rightarrow C_2H_6$$
$$MC_2H_6 \rightarrow M.CH_3 + MH_2 \rightarrow 2CH_4$$

could be established.

Laboratory Control of the Corrosion of Distillation Equipment and of De-Salting Processes—L. L. Davis, J. M. Jones and C. A. Neilson, before AMERICAN PETROLEUM INSTITUTE, Wichita meeting, May, 1938.

Since corrosion of distillation equipment may be due to hydrogen chloride, hydrogen sulphide, sulphur dioxide, dissolved oxygen, organic acids or water, the first task of the control chemist is to ascertain which of the above six agents is to be combatted, and to select appropriate counter measures. The author illustrates the matter by describing two typical distillation operations and the prevention methods used. The first case involved the distillation of an acid-treated cracked distillate where sulphur dioxide was the only corrosive agent, and steel and cast iron the only metals injured. They devised a laboratory method for determining the amounts of sulphur dioxide and dissolved iron in the effluent streams and a scheme for using these figures for indicating the amount of gaseous ammonia to be injected into the distillation system to neutralize the sulphur dioxide.

They decided it were better to remove the source of corrosion, before charging, by installing a Stratford continuous treating process which gave a treated product with a minimum of sulphuric-acid treating products. Thereupon, with a minimum consumption of ammonia in the still, the loss of iron was reduced to zero.

The other case is that of preventing corrosion of crude oil distillation equipment where the metal is subject to the combined attack of hydrogen chloride and hydrogen sulphide.

Here the first part of the control chemist's problem is to supervise the de-salting of the crude. The next and most difficult problem is to supervise the injection of ammonia into the distillation system so as to maintain a pH that will protect the metal. This is a relatively simple proposition where iron or steel is the only metal involved, but where brass or bronze fittings are used the maintenance of a pH that will not harm the brass and at the same time protect the iron is a somewhat delicate task. Very full directions for making the necessary tests and determinations are given.

Structure of Lubricating Greases—A. S. C. Lawrence, in JOURNAL INSTITUTION PETROLEUM TECHNOLOGISTS, vol. 24 (1938), No. 174, pp. 207—220.

Soap-oil systems exist in three forms: true solution, true gel and pseudo-gel, which is a paste of micro-crystals. Commercial lubricating greases may be in stage two or three. There is a well-defined temperature of transition from two to three which depends on the nature of the soap used and upon the presence of polar substances, such as fatty acid, water or glycerin, which lower it. These greases are not emulsions. Natural greases such as butter and tallow are emulsions in which the dispersion medium is a soft solid. Dispersion of the soap in the oil can be brought about by stirring at any temperature above that of the transition and does not require raising to that of true solution. Formation of gel and pseudo-gel are crystallizations and the mechanical properties of the systems are due to the peculiar crystal habit and properties of the separating soap particles. The properties are profoundly modified by small amounts of fatty acid.

PHYSICS

Pressure Distribution in Oil and Gas Reservoirs by Membrane Analogy—Aaron J. Miles and Eugene A. Stephenson, in PETROLEUM TECHNOLOGY, vol. 1 (1938), No. 2; Technical Publication No. 919, 11 pages.

The pressure distribution in a producing oil or gas reservoir has been obtained mathematically in a limited number of special cases where the boundary of the reservoirs are simple geometric figures with the wells conveniently located within them. Using some of the previous work as a basis, it can be proved that a number of additional problems of pressure distribution can be solved by use of soap film. This method is particularly applicable to a reservoir drained by a number of wells, or to a reservoir of irregular shape, or to both. Since this method obtains the pressure distribution, it also establishes the drainage boundaries of the wells.

This paper derives the analogy between the equation representing the pressure distribution in a reservoir and the equation of the deflected membrane. It also describes the apparatus and the method of operation. The experimental method is employed to solve a problem whose mathematical solution is known and the results compared. These are found to be in good agreement.

The method is applicable to any homogeneous liquid, compressible or incompressible, or to a gas, flowing in a reservoir of uniform thickness, permeability and porosity. The flow state may be either the steady state or the transient state wherein the density or pressure of the fluid in the reservoir declines at a constant rate.

ASPHALT AND TAR

Exudation Test for Bleeding in Bituminous Roofing—G. L. Oliensis, in IND. ENG. CHEM., Analyt. ed., vol. 10 (1938), No. 4, pp. 199-201.

Bleeding, or strike-through, by which is meant the exudation of unsightly black spots occasionally noted on the surface of ready roofing, is due to a peculiar type of incompatibility, as yet unexplained, between the asphalt used as saturant and that used as coating. During the last seven years the author has developed an exudation test for determining this lack of compatibility between the saturant and the coating, before their use in roofing manufacture.

The test is made by dusting the coating with a layer of fine talc and placing a drop of the saturant on the talc-covered surface and keeping the sample under observation for 72 hours at 110 deg. F. If the two materials have no strike-through tendencies, nothing will happen; in the contrary case a ring of a darker color will form around the drop of saturant.

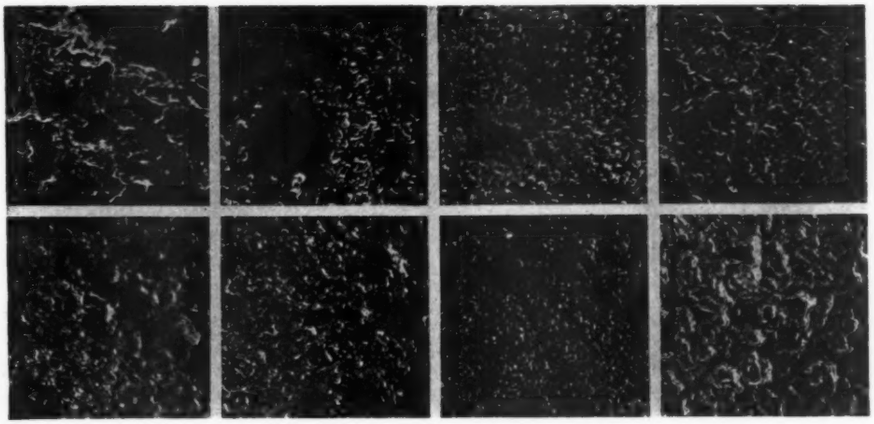
Several years of practical experience with the exudation test have led to the conclusion that while it is safest practice to use only saturants and coatings that show no ring whatever in that test, no visible bleeding will occur in roofings made with a saturant and coating that in the standard exudation test at 110 deg. F. develop a ring not wider than 0.5 mm.

Structure in Asphalts Indicated by Solvent-Treated Surfaces—R. N. Traxler and C. E. Coombs, in IND. ENG. CHEM., vol. 30 (1938), No. 4, pp. 440-443.

Asphalts are usually considered to be protected lyophobe sols made up of soft, rather fluid material as the medium, and harder carbon compounds of higher molecular weights as the dispersed lyophobe portion. A study of their flow characteristics indicates that asphalts do possess varying degrees of internal structure, depending on the source of material, method of processing and temperature at which the rheological test is made.

The authors have found that asphalts which show distinct anomalous flow characteristics, as manifested by a high rate of age hardening, marked elastic properties, etc., give surface designs when treated with partial solvents such as ethyl ether and 86 deg. Be. naphtha. On the other hand, asphalts that are essentially viscous show no such designs. This opens a new method of characterizing asphalts, particularly as the presence of a surface pattern revealed in this manner indicates the presence of structure in the asphalt. Different patterns are obtained according to whether ether or naphtha is used for etching and these patterns are reproducible. Furthermore, different asphalts give different patterns with a particular solvent, so here is a possible means of identification as to type, source and degree of processing. Though the designs probably indicate the presence of structure, they do not necessarily show what the structure actually is. Some characteristic patterns obtained with ether, greatly enlarged, are shown in the accompanying illustration (left, after one hour; right, after one month).

TREATMENT. Tin containers 5.5 cm. in diameter and 0.7 cm. deep (the lids of three-ounce penetra-



Change in surface patterns of asphalts treated with ethyl ether (X 222). Top: after one hour. Bottom: after one month.

tion tins) were filled with the asphalt to be investigated. The samples were placed in a closed box at atmospheric temperatures to protect the asphalt surfaces from dust but to permit contact with air. A sample was removed from the box after any desired interval of time. A small quantity of the solvent was poured on the surface and allowed to remain about five seconds and then whisked off. If, after evaporation of the small quantity of solvent remaining, a design had not appeared on the surface, the treatment was repeated. Usually two applications of solvent were sufficient, but in some cases three were necessary.

Although the patterns change with the age of a sample from the time of pouring and with a change of solvent, good reproducibility of design can be obtained with most asphalts at a given age using a particular solvent.

Aerometric Determination of the Characteristics of Tar Oils—R. Heinze and F. Peschke, in BRENSTOFF-CHEMIE, 1938, pp. 81-87.

Recent work by Heinze and Marder has resulted in setting up formulas by which the heat value, the elementary composition and the cetene number of a tar oil may be calculated from the density, supplemented in certain cases by distillation data.

To test the reliability of these formulas the authors examined a series of 37 tar oils and have found that these formulas are applicable within the usual conditions of practice.

New Method for Recovering Asphalt from Pavement Samples—Hermann Suida and H. Hoffmann, in PETROLEUM, vol. 34 (1938), No. 4, pp. 1-4.

The method heretofore in use for recovering asphalt or bitumen from large samples of road coats involves considerable trouble and is not entirely reliable, because the solvents used (carbon disulphide or chloroform) are not chemically inert. Instead, the authors employ pure benzol. In their method the sample (which may amount to two or three kilograms) is enclosed in a cloth bag and suspended below a copper condenser coil attached to the lower face of a five-liter autoclave; below the bag is placed a 600 cc. beaker containing 300 cc. of benzol. When the cover has been put on, the autoclave is set in an oil bath; the air in the autoclave is displaced by pure carbon dioxide gas and the bath heated to 120 deg. C. for one hour. The pressure, as shown by a manometer, will rise to about two atmospheres. What the operation amounts to is a reflux extraction under pressure in an atmosphere of CO_2, which excludes the possibility of chemical decompositions. After cooling the extract is centrifugaled to remove filling material and the benzol is distilled off until a temperature of 130 deg. C. is reached, and the residual asphalt examined for softening point and penetration. The method is applicable to all kinds of asphalt-bitumen mixtures and in practice has given unobjectionable results.

USE

Economic Aspects of the Pawhuska Road Tests—W. W. Scheumann before WESTERN PETROLEUM REFINERS' ASSOC., Hot Springs meeting, April, 1938.

This paper reports the results of road tests in the summer of 1937 on the performance of fuel systems of representative cars of the 1937 model automobiles. The 9 test cars were driven approximately 10,000 mi. during a period of three summer months.

Ignoring the technical features relating to road test technique developed by this work, and confining the conclusions reached only to the economic aspects, it may be stated:

The fuel system characteristics of the nine 1937 model cars tested vary considerably.

From the standpoint of permissible vapor pressures, if the poorest car were improved to equal the best, the refining industry could utilize additional butane in motor fuel amounting to 1.226 percent of the annual motor fuel requirements. It is estimated this would net the industry at least $16,000,000 annually, and, in addition, decrease lead expense by $1,800,000.

Fuel losses from rear tanks and carburetor vents will run from four to seven percent in hot weather, and higher, depending upon the type of driving. A conservative annual estimate of 1.96 percent minimum loss has been made by the writer.

In hot weather this accounts for octane number losses of 1.1 to 2.0 octane numbers, and will average at least 0.54 octane numbers on an annual basis. In terms of lead, this antiknock loss is valued at approximately $2,000,000.

An annual fuel loss of 1.96 percent from the car costs the consumer at least $65,000,000.

Ascertaining the Aging Tendency of Motor Lubricating Oils—Seufert, in OEL UND KOHLE, vol. 14 (1938), No. 12, pp. 239-241.

Existing methods of investigating the aging propensities of mineral oils do not give concordant results, for two principal reasons: first the conditions under which the tests are made are artificially exaggerated and intensified in order to complete the test within a reasonable time; and secondly, the methods of separating the alteration products are faulty.

The most reliable method appears to be that proposed by Noack, in which a sample of the oil is heated for one hour at 250 deg. C. and under a slight vacuum represented by a 20 mm. difference in level on a water manometer. After cooling the oil is diluted with a standard gasoline and treated with fullers earth. Then the solution is poured off and the fullers earth extracted with chloroform; after evaporation of the chloroform the residue is weighed; the amount of this residue is regarded as the measure of the aging tendency of the oil. The oil should be treated with fullers earth before being subjected to the heating processes to ascertain the amount of resins, etc. already present. Some oils may have large original amounts of impurities, which may be increased only a little by heating, while other oils with small original residues may show a large increase as a result of the test. Hence it is the difference between the before and after tests that is the real indicator of the oil's quality.

The chief objection to the original Noack test is that complete extraction of the adsorbed substances by the chloroform is a slow process. It is now found better to use a 1:1 mixture of benzol and alcohol for the extraction instead of chloroform.

Controlling the Combustion Process in Internal Combustion Engines by Analysis of the Exhaust Gases—Emilio F. Franchi, in BOLETIN INFORMACIONES PETROLERAS (Buenos Aires), vol. 14 (1937), No. 158, pp. 41-67.

In this investigation the author analyzed the exhaust gas of an ASTM-CFR motor which was operated under standardized conditions and at known rates of fuel consumption. The fuels operated on were straight run airplane gasoline, cracked airplane gasoline, pure alcohol, mixtures of airplane gasoline and alcohol, pure benzole, mixtures of airplane gasoline and benzole, and super gas (propane).

From the large mass of analytical data obtained it is concluded that the analysis of the exhaust gases gives an accurate picture of the combustion process within the motor. With a fixed rate of carburetion and admitting the fuel mixture at a constant temperature, the variations of the surrounding atmospheric conditions have no apparent effect on the composition of the exhaust gas. The process is also not altered when the compression ratio is raised to the knock point, provided the other conditions remain unchanged.

Under these conditions it is possible to calculate the number of calories generated in the motor by different fuels from the analysis of the exhaust gas. These calculations indicate that the combustion of mixtures of straight run airplane gasoline and alcohol within certain proportions generates a larger number of calories than the pure gasoline, notwithstanding the inferior calorific value of the alcohol. The same holds for mixtures of cracked gasoline and benzole, whereas cracked gasoline yields more calories than straight run gasoline. The super gas yielded more calories than any of the other fuels.

Relation of Aging Qualities of Lubricating Oils to Their Sulphur Contents—W. Kley and R. Gottschalk, in OEL UND KOHLE, vol. 14 (1938), No. 11, pp. 220-223.

Experience with the various kinds of autom tive fuels now used in Germany, including gen rator gas brown coal distillates, and normal petroleum prod-

ucts, have brought to notice unsuspected differences in the aging characteristics of lubricating oils used in the engines; some oils which gave satisfactory service in normal Diesel operations were found to have very short lives when used in conjunction with some of the substitute fuels, while other lubricating oils in the same service performed satisfactorily. Investigation showed that the differences in the aging characteristics of these oils were correlated with their original sulphur contents. A lubricating oil with a low original sulphur content is very little affected by the sulphur content of the fuel, whereas if the original sulphur content of the oil is high, this sulphur acts catalytically to cause the oil to absorb more sulphur, to an extent that renders the oil unsuitable for further use. This indicates that lubricating oils destined for use in gas motors, or in other uses where the fuel contains appreciable amounts of sulphur, must be judged from a different standpoint and be more carefully examined than is usual when engines are operated with fuels of normal characteristics.

Regeneration of Used Oils and its Possibilities—P. M. Edmond Schmitz, in BULL. ASSOC. FRANCAISE DES TECHNICIENS DU PETROLE, 1938, No. 42, pp. 5-42.

This paper is interesting chiefly from the fact that it contains a very extensive review of the whole question of reclaiming used lubricating oils. Numerous apparatus and processes employed in the United States and other countries are mentioned and more or less extensively described.

Attention is again called to the fact that a used and regenerated oil may not be quite the same as a fresh oil, and not necessarily inferior. A reclaimed oil may be more stable, as is shown by comparative artificial aging tests. In such tests, and in practice, the reclaimed oil never shows the same degree of oxidation or aging as will the fresh oil. In this sense an oil may be said to undergo a sort of refining in use, by which unstable or susceptible constituents are destroyed or changed so that they may be removed in the reclaiming process.

The author also refers to a point which it appears no one has yet thoroughly investigated. This is the possibility that in addition to the destruction of unstable components during prolonged use, there may occur changes in the chemical nature or molecular structure of lubricating oil, with formation of new hydrocarbons of a superior type. The author claims to have found in a regenerated oil a component of high flash point, low viscosity but lower coefficient of friction than could be isolated from the fresh stock of the same oil. By treating used oils with selective solvents, or subjecting them to a critical process of fractionation it might be possible to find similar instances of new and more valuable products.

SUBSTITUTES

Power Alcohol—Report of Commonwealth Fuel Adviser, in AUSTRALIAN SUGAR JOURNAL, vol. 39 (1938), No. 12, pp. 725-726; 739-748.

At the present time, the only firm preparing alcohol in Australia for motor fuel is the Australian National Power Alcohol Company. The distillery is equipped for fermenting both molasses and cassava, etc., but only molasses is used as the raw material. The plant has an installed capacity of 1,250,000 gal. per annum, but owing to the limited demand for power alcohol, the distillery is operated for only six months in each year. The product is sold to petrol distributors under conditions prescribed in the Motor Spirit Vendors' Act. The ex-works price is based upon the wholesale price of petrol, and at present is in the region of 1s. 6d. per gal. Delivered into the distributors' bulk storage tanks, the alcohol costs 1s. 9d. per gal. or 8d. to 8½d. in excess of the landed price of imported petrol with duty and primage paid.

At the moment, the oil companies are compelled to purchase 1½ gal. of alcohol for each 100 gal. of petrol imported into Queensland for consumption with the State. The alcohol is blended with petroleum spirit, usually in the proportion of 15 : 85 by volume and is sold as "Shellkol," "Plumekol," etc., at a price ½d. per gal. below that of standard grade petrols. To recoup themselves for the higher cost of alcohol, and the lower retail price of the blend, the oil companies have raised the price of petroleum spirit throughout the State by ½d. per gal. In Brisbane, standard and super grades of petrol are sold at 1s. 9½d. and 1s. 10½d. per gal. respectively, as compared with 1s. 9d. and 1s. 10d. in Melbourne, and 1s. 8d. and 1s. 9d. in Sydney.

No difficulty is experienced in disposing of the small quantity of alcohol fuel at present on the Queensland market. The oil companies do not seek to extend their sales of alcohol, however. The product is not advertised, attention is not drawn to such virtues as it possesses, and it is offered for sale only sufficiently widely to effect the disposal of the prescribed quantity.

Under conditions now prevailing the sale of alcohol for use as motor fuel in Queensland costs the country about £45,000 per annum, of which about one-third is found indirectly by the Commonwealth government and the rest by the Queensland motorists, who have not considered the burden sufficiently onerous for complaint, but any further extension of the industry might become irksome.

The vital point at issue in estimating the cost of producing power alcohol is the price to be paid for the raw material. If mill owners were to refuse to make molasses available to distilleries, at a uniform price to be charged to all consumers indiscriminately, then the cost of molasses alcohol might well be 1s. 6d. per gal. instead of 1s. 4d. Also, before committing themselves to any action in fermenting B. syrups, the distilleries would need a binding assurance that syrups would be made available to them for a number of years, in adequate quantities, and at an equitable price which has been assumed to be £2 6s. 0d. per ton ex mill.

Germany's Progress in Oil Self-Sufficiency—Oskar Tokayer, in PETROLEUM PRESS SERVICE, vol. 5 (1938), No. 6, pp. 61-64.

The summer of 1938 will mark the end of the four-year period within which Germany was to become independent of foreign liquid fuels.

It is a fact that domestic production of liquid fuels has made important progress. Imports of gasoline have been decreasing and last year (1937) were 20 percent under imports in the preceding year. Total production of synthetic gasoline in 1937 was 850,000 tons, an increase of some 500,000 tons over production in 1936, and brought the contribution of domestic supplies to Germany's total requirements of light motor fuels from 43 percent up to 62 percent. Although this represents considerable progress, complete independence in the sphere of light motor fuels is still somewhat remote.

With other mineral oils the case is different, and there is little at present to indicate Germany's ability to dispense with foreign supplies of these for many years to come. The production of these oils from domestic sources on any considerable scale has hardly begun yet, whereas requirements, as may be seen from the following table, are steadily increasing:—

German Total Mineral Oil Consumption

	1937	1936	Inc. in %
Light Motor Fuel	2,450,000	2,235,000	9.6
Gasoline for "technical" purposes	150,000	140,000	7.1
Kerosene	110,000	110,000	—
Lubricating Oils	500,000	460,000	8.7
Gas Oil*	1,200,000	1,050,000	14.3
Fuel and Diesel Oil Burners†	460,000	430,000	7.0
Asphalt	550,000	500,000	10.0
	5,420,000	4,925,000	10.1

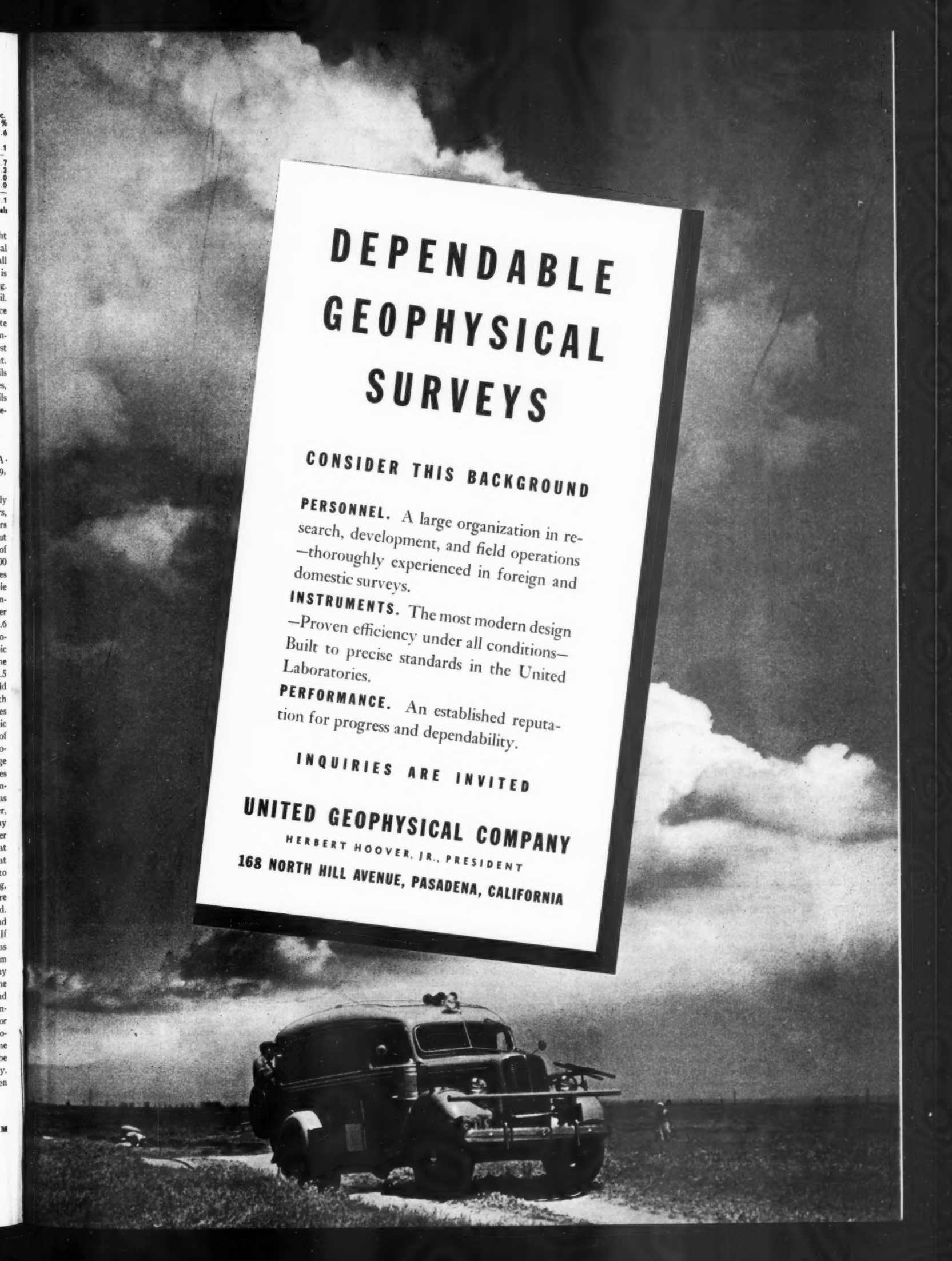
*Including kerosene for tractors; †For supply to German vessels only.

Requirements of oil products other than light motor fuels thus represent 54.6 percent of total German oil demand and the consumption of all of these, with the exception of kerosene, which is of secondary importance, is rapidly expanding. This applies particularly to the demand for gas oil. From all of which there seems to be no evidence that Germany is anything like approaching a state of self-sufficiency in liquid fuels generally. The continuous increase in gas oil imports, now the biggest item in foreign purchases, is especially significant. Developments in the production of Diesel fuel oils from domestic sources are still in the initial stages, and there is no indigenous output of these oils apart from the modest quantities obtained by refining domestic crudes and lignite by-products.

Long Distance Travel with City Gas—A. Henke, in OEL UND KOHLE, vol. 14 (1938), No. 9, pp. 179-181.

A one-ton Opel-Blitz truck, which ordinarily consumed 17 liters of gasoline per 100 kilometers, was fitted with four gas drums holding 219.4 liters of city gas under 215 atmospheres pressure (about 3,200 lb. per square inch), and with 90 percent of a full load made a round trip of 300 kilometers (200 miles) between Hannover and Dusseldorf. Facilities for refueling with compressed gas were available along the route. The road lay partly over a mountainous terrain. Average fuel consumption, after everything was in proper adjustment, was 23.6 cubic meters (829 cu. ft.) of gas per 100 kilometers. For comparison, an average of 1.6 cubic meter (56.5 cu. ft.) of gas is the equivalent of one liter of gasoline (one gallon gasoline equals 213.5 cu. ft. of city gas). The entire trip, which would have required 210 liters of gasoline, was made with 339 cubic meters of city gas. At the relative prices of 40 pfg. for gasoline, and gas at 12 pfg. per cubic meter, the use of city gas represents a saving of 51.5 percent. (It should be remembered that gasoline in Germany is heavily taxed). The average speed, part of the time through fog, was 25 miles per hour. The experiment is considered to demonstrate the practicability of substituting city gas for gasoline for long distance trucking. However, although there are now some 50 points in Germany where trucks can obtain city gas and methane under pressure, there are still too many such stations that are separated by more than 100 miles. It is true that a gas-propelled truck may carry enough gas to travel more than that distance without refueling, but for convenience these stations should be more numerous if this use of city gas is to be generalized.

(This experiment seems to carry a more profound implication than might appear at first sight. If driving a truck with gas is as easy and relatively as inexpensive as that, a country without petroleum deposits but plenty of coal should find autarchy in motor fuel greatly simplified. It also raises the question as to the real necessity of building and operating great plants for producing gas to be converted into gasoline (Fischer-Tropsch process) for the use of motorists. Since the gas has to be produced as a necessary preliminary to the gasoline synthesis, the latter operation would seem to be superfluous because the gas might be used directly. The art of gas manufacture from coal has long been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established on an efficient and economical basis, and under certain conceivable conditions in certain countries may yet provide respectable competition to the petroleum industry, particularly if petroleum reserves fail to keep abreast of consumption.—ED.)

RESERVES

Oil in Australia—I. C. H. Croll, in MINING AND GEOL. JOUR. (Victoria); vol. 1 (1938), No. 2, pp. 57-65.

From the geological point of view the most unlikely petroliferous formations in Australia are those younger than Carboniferous in age. Victoria is the only State in which a substantial quantity of oil has yet been found, chiefly in the township of Lakes Entrance. The oil here occurs in a Glauconitic sandstone of Upper Oligocene age about 31 ft. in thickness at a depth of 1,238 ft. Of the 39 wells that have been drilled, 28 obtained oil in amounts varying from a few drops to about 138 bbl. a day. A small amount of dry gas, principally methane, is associated with the oil and in one case has been used for lighting and heating at the well-head. The oil obtained contains no gasoline or kerosene fractions. At the present time only a single well is in active operation. Numerous other holes have been sunk through the tertiary in this region without encountering a trace of oil. A number of favorable structures have been recognized in various parts of the continent, but aside from the Lakes Entrance field the only tangible result has been the discovery of a few gas horizons.

How Much Crude Reserves has U.S.S.R.?—L. David Wosk in OIL WEEKLY, vol. 89 (1938), No. 8, p. 26.

This is the concluding number of a series of seven articles in which the author discusses each of the oilfields scattered throughout the Soviet nations—Azerbaijan, North Caucasus, Emba, Urals, Turkmenia, Middle Asia, Sakhalin, etc. The geology, structure, production and prospects of these various areas, together with such statistics as are available, are discussed in extenso.

After a thorough consideration of the areas visited, as well as the special conditions confronting the Soviet oil industry, the author feels that the Soviet reserves are great, sufficient to meet her increasing demands for many years. Though their production at present is concentrated mainly in Azerbaijan, new areas will be developed in the next five years to remedy this over-concentration. Their geological and geophysical technique has made great progress, in some respects being equal to that used in the most modern fields of the United States. Due to the wide variety of complex geology encountered over such a vast area, considerable time will elapse before sufficient trained personnel will be developed to cope with the entire situation in the detailed manner required for an adequate development program. A great deal of credit must be given Soviet geologists for the splendid work that they have done under the circumstances.

The advance in drilling technique has not kept up with the geology, though it is rapidly improving; the lack of light portable equipment, in addition to increasing costs of production, has slowed down development, but this situation is now being remedied.

A jump in production, as well as in efficiency, can be looked for in the next five years.

Production practices are far behind those of most countries; the Soviets recognize this defect and are studying modern production practices (applying some now) preparatory to placing them in operation as soon as possible.

Growth of Soviet internal needs precludes any possibility of large scale exports for many years.

The two outstanding requirements of the Soviet oil industry today are: (a) Peace (war would disrupt the entire program); (b) more trained personnel. The personnel can be and is being trained; the Russians are capable of being developed into good workers in both skilled and unskilled departments. The Soviet equipment manufacturing plants are progressing; their equipment is improving in both quantity and quality, and this improvement will continue to increase as the quantity and quality of their metallurgical industry increases (which is rapidly taking place).

The Soviet petroleum industry generally, though not evenly in all departments, is advancing; in time it will be comparable in both size and efficiency with the most advanced in the world.

ECONOMICS

Geological Limits to Oil Law—Wm. W. Porter II, in BULLETIN AMERICAN ASSOCIATION PETROLEUM GEOLOGISTS, vol. 22 (1938), No. 5, pp. 565-573.

In this paper the author enters an objection to proposals for discarding the rule of capture in favor of the rule of ownership in place. He bases his proposition to retain the rule of capture on the ground that ownership of oil and gas cannot be determined on any other basis; the fact is, he says, that now after 75 years of oilfield development not enough is yet known about underground conditions to determine and apportion oil among surface owners with any approach to accuracy.

An example is the Santa Maria Valley field, a major California field discovered in 1936, which field illustrates the impossibility of compulsory acreage allocations, and the impossibility of determining ownership in place by engineering methods. A 4,000 bbl. well was offset 660 ft. by a 150-bbl. well. Two wells exactly one-half mile apart produced approximately 3,000 bbl. per day and 700 bbl. per day, respectively, while an offset on a straight line between them produced only 250 bbl. per day. Two wells approximately 1,400 ft. apart were each producing less than 400 bbl. per day. A well drilled on a straight line between them produced more than 1,500 bbl. per day. It is necessary to drill to find out how much oil exists in place under various lands. As all these discrepancies occur between wells less than 700 ft. apart, and within the total limits of the field, the futility of determining ownership in place is apparent. After the subsurface characteristics of such a field are reasonably well known, and the good and bad spots are discovered by drilling, the problem is solved, too late for the principle of ownership in place to have any value.

Other instances of the same general kind are cited and discussed.

Influence of Military Use on World Oil Markets—Denis S. Sneiger in OIL WEEKLY, vol. 89 (1938), No. 10, pp. 45-46.

With the continued mechanization of the armies of the world and the increase in size of these armed forces as well as naval expansion programs and the construction of larger fleets of airplanes, war or the threat of war directly affects the crude markets of the world. And in turn, oil has become a vital necessity to a nation involved in war or in the preparation for war.

Figures on the amount of oil imported for military purposes by various world powers are generally unreliable or otherwise impossible to acquire. However, figures issued by the United States Bureau of Mines on the amount of oil imported by various countries reveal some interesting facts and show a definite trend not only to the more aggressive dictator-ruled powers such as Japan, Germany and Italy, but also to the two other European powers which would be involved in any continental war—Britain and France.

Japanese imports have more than doubled since 1933. In that year Japan imported 14,595,000 bbl. of crude and heavy oil and in 1937 it is estimated that more than 32,000,000 bbl. were imported. This estimate is based on the reported import figures for the first six months of 1937.

In Italy and Germany, the imports of crude oil began a rise in 1934 which continued through 1937. In Italy the rise was especially sharp from 1936 to 1937, the imports for 1936 being 2,196,000 bbl. of crude oil and for 1937, 6,550,000 bbl. In Germany the increase was not so pronounced, being little better than 1,000,000 bbl. of crude increase for 1937 over the preceding year.

Imports of crude oil to France began an upward swing in 1931, but the sharp increase took place in 1933. In that year, France imported roughly 19,000,000 bbl. of crude as against 7,000,000 in the preceding year. Since then France has continued to increase her crude imports which in 1937 totaled more than 45,000,000 bbl.

On the other hand, imports of crude oil into Britain have been at a fairly steady pace but imports of finished products have increased.

These facts point to an accumulation of stocks for military purposes. How important these accumulations may be is not known, but undoubtedly they have some influence on the world oil market.

GENERAL

Bibliography of Geologic Structure Maps—Olive C. Postley, in BULL. AM. ASSOC. PETROLEUM GEOLOGISTS, vol. 22, (1938), No. 4, pp. 431-482.

There is here compiled a list of structure maps and cross sections of areas that have been exploited for oil and gas in areas east of the Mississippi River and some producing states in the Mid-Continent region—published for the convenience of those interested in the technology of oil and gas. The entries amount to about 1,000 and relate to fields or occurrences in 15 states: Alabama, Arkansas, Illinois, Indiana, Kansas, Kentucky, Louisiana, Michigan, Mississippi, Missouri, New York, Ohio, Pennsylvania, Tennessee and West Virginia.

The references here given will be of undoubted convenience to workers in petroleum geology.

Application of Bailey's Theory to Tube-Stress Calculations—C. O. Rhyss, before AM. PETROLEUM INSTITUTE, Wichita Meeting, May, 1938.

The general purport of this paper is to show the compatibility of R. W. Bailey's theory of creep stresses with the general operating conditions of tubes in refinery equipment.

In the introduction it is pointed out that, before the advent of Bailey's theory, a method of calculation, based on the combined work of Lorenz and Lamé, was used. This method applies only to conditions which do not include the cases of high metal temperature and high creep rate occurring in cracking-coil work. For such cases the method of Bailey, based on creep phenomena, is much more suitable.

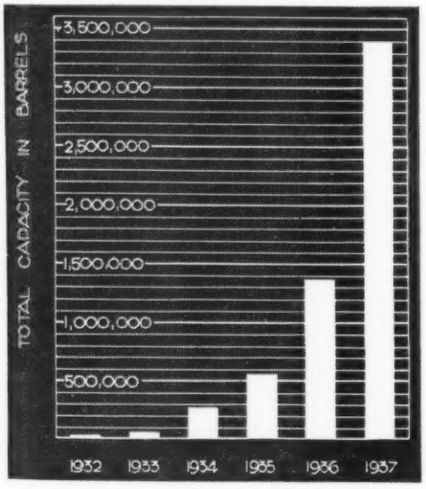
Elastic temperature stresses are then discussed. It is explained that they cause fracture only in materials which are elastic up to the breaking

point—like glass and cast iron. Where there is a considerable range of ductility—as in most tube material—it is practically impossible for rupture to occur due to temperature stress. Reference in support of this is made to current boiler practice and to destruction tests carried out by Standard Oil Development Company. Why, in spite of this, furnace tubes cannot be designed on a basis of pressure stress only is explained by considering the effect of heat transfer on pressure-stress distribution and metal-strength variation through the tube wall. A numerical example is given, showing that high-metal-temperature conditions govern tube design.

The form of equation most suitable for tube-stress calculations is presented. The equation is of such a form that, for a known working stress, the tube proportions can be found directly without any cut-and-try methods. This saves a considerable amount of time in determining tube sizes.

New Developments in Petroleum Storage Vessels—D. E. Larson, before AM. PETROLEUM INST., Wichita meeting, May, 1938.

The trend toward higher vapor pressures in motor fuels emphasizes the economic necessity for vessels designed to store volatile liquids without deterioration or loss by evaporation.



Methods commonly employed for reducing losses from volatile liquids include elimination of air circulation in the vapor space, reduction of temperature variation, elimination of vapor space, the use of variable vapor space, and storage under pressure. Well-known applications of these methods are the use of gas-tight fixed roofs with conservation vents, reflecting paints, water-top roofs, water-spray systems, insulated roofs, sunshades, breather roofs, lifter roofs, water-displacement systems, floating roofs, and pressure vessels.

More recent developments include the use of improved floating roofs for working tanks, balloon systems for existing storage tanks, balloon roofs for marketing tanks, and Hortonspheroids for a wide range of volatile products including all motor fuels and natural gasolines.

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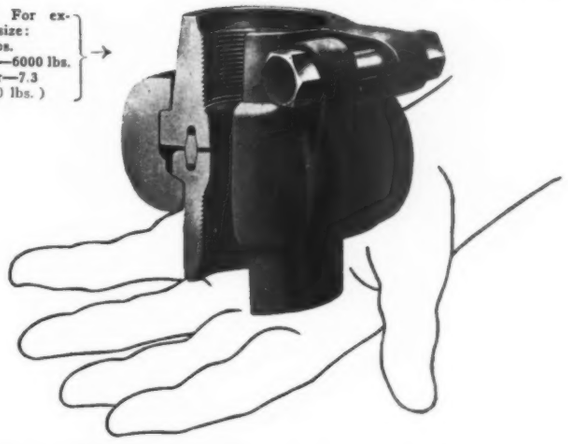

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BOOKS

Petroleum Comes of Age, by Albert A. Lawrence; published 1938 by R. H. BARTLETT, Tulsa, Okla., 227 pages; $2.25.

This book gives a lively history of the American petroleum industry from the beginning, with particular reference to the early phases, and more particularly still to the petroleum history of the two Oil Creek regions tributary to the Allegheny, the one in New York State which includes the Cuba (or Seneca) oil spring, and the other around Titusville in Pennsylvania.

It was in these regions that American oil began its spectacular career, but the author does not follow it much beyond the land of its birth, nor does he carry the story much beyond 1880, when the industry became of age and was ready to take up the Herculean task imposed by the advent of the automobile.

In bringing to light the early discoveries and practices it has been made clear that the oil industry was really born long before 1859, and had already acquired the fundamentals of its technique when the famous Col. Drake appeared on the scene. The author has made a most interesting account of those far-off days, and he should have every cultured oil man for a reader.

Publications of the Main Committee of the Central Office for Asphalt and Tar Research (in German), published 1938 by ALLGEMEINER INDUSTRIE-VERLAG, Berlin; 600 pp. with numerous illustrations and tables, RM. 18.

This book treats of research and development work on asphalt and tar, their properties, uses and tests. Most of the book is devoted to detailed discussion of the activities of the Central Office for Asphalt Research from 1919 to-date. This work has covered, from the German standpoint, practically every phase of asphalt research and applications. A 36-page index carrying 2,000 entries is necessary to indicate the subjects treated. It contains a mine of information which should prove useful in asphalt engineering nearly anywhere.

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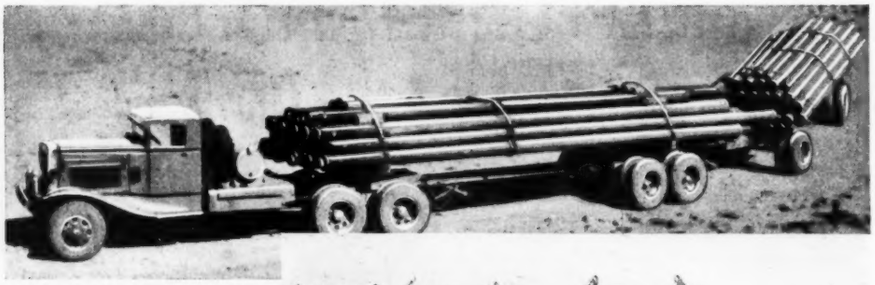

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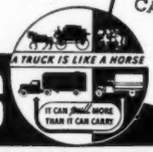

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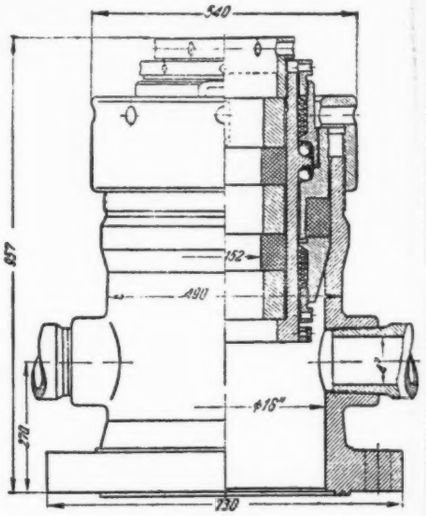
RUSSIA

(Continued from page 102)

(L4-760) with the following basic advantages over the old type equipment: increased loading capacity; increased speed of lifting and sinking operations; improved conditions for operation of chains, cog wheels and couplings, all of which were improved in design and construction; minimum wear of cable, due to increased diameter of drum and better winding of the three rows of cable; improved portability without dismounting, double lever brakes; and hydromatic brakes.

The first test with this new hoist was made at Baku, drilling to 8,100 ft. Drilling was started with a six inch pipe, using a 21¾ in. PX bit. During the first four days 1,435 ft. were drilled. After reaming, a 16 in. conductor was sunk and using the same six inch pipe, but with a 15¾ in. bit, the hole reached 4,385 ft. in 13 days. During the following 27 days, drilling was carried out with a 13¾ in. bit, and again six inch pipe, to a depth of 5,850 ft. Drill pipe was then reduced to four inch size, and an 11¾ in. bit employed; with which the 6,000 ft. level was reached within the following 30 days. During the entire period bits were changed 46 times, of which 40 changes were below 3,900 ft.

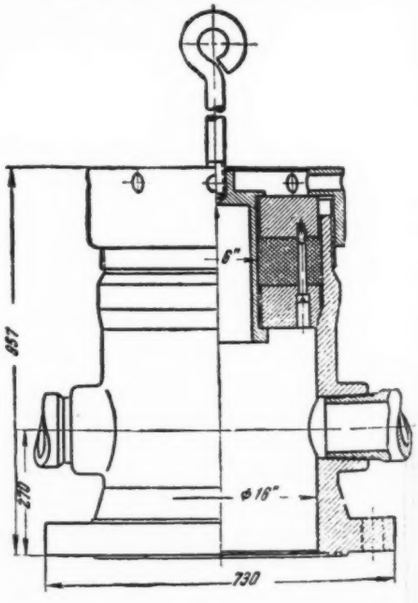
Drilling conditions were not favorable, but the hoist operated without trouble, the brakes showed little wear, brake washers did not become overheated, and the cable worked satisfactorily. As a result the Lieut. Shmidt plant began to manufacture the hoist under mass production methods.

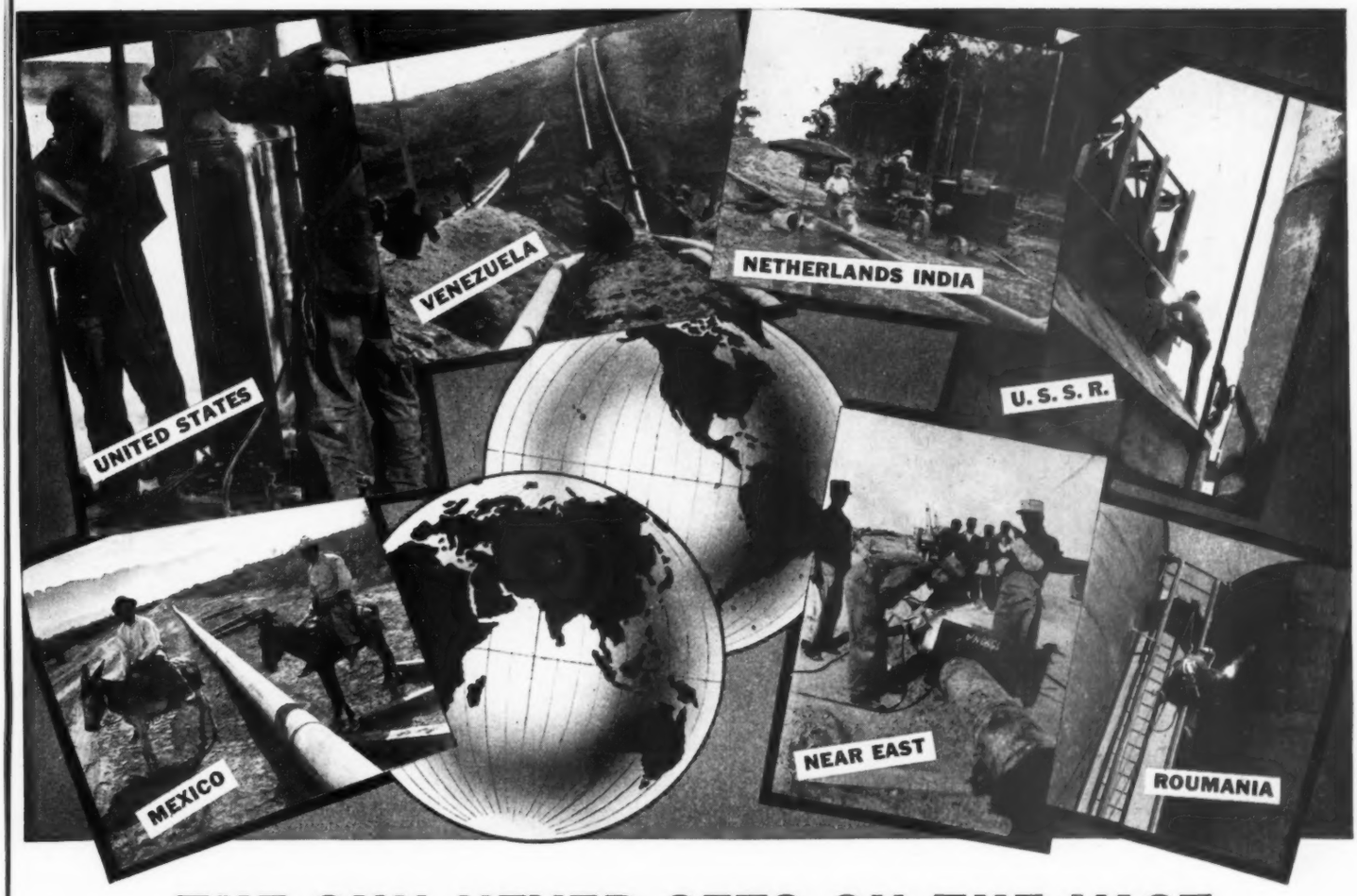


Universal preventor capable of handling 12 in. diameter casing under pressures of 100 atm.

Closed type rotor R 700-S2 has advantages over previous types as it enables continuous operation at a speed of 200 r.p.m., while basic roller support and lower ball support enable a fair distribution of horizontal and vertical loads to eliminate

Another view of the preventor with 100 atm. pressure capacity, weighing 1¼ tons.





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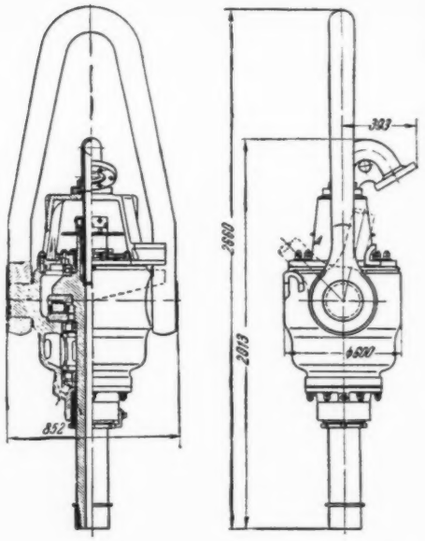
SHEAR-RELIEF VALVE

(Continued from page 116)

shaking. The improved lubricating system prevents leaking or contamination. Designed for depths down to 10,000 ft., the rotor was tested by drilling to 4,000 ft. at Baku—its operation thus proven satisfactory, it was taken to other wells for further use.

Universal blowout preventors of 12 and 16 in. diameter PUS are entirely new in drilling practice, and their advantage lies in the simplicity and reliability of design which insures complete hermeticity of wells drilling in oil sands under gas pressure. The revolving socket mounted on a square rod inside the preventor enables drilling under well pressure. The preventor was tested at Baku by drilling to 1,250 ft. under gas and sand eruption between 10 and 70 atmospheres, and drilling was continued successfully at 2,250 ft. under pressure of 20 to 50 atmospheres. The 16 in. preventor differs from the others by the bayonette coupling, which closes automatically, while a lever mounted in the well unlocks it. This latter type of preventor is still undergoing tests.

Hydromatic brake GTI-915 meets all requirements of modern Soviet drilling technique, and has advantages over mechanical brake systems. It decreases vibration and reduces wear and overheating of brake plates and pulleys. Hydromatic brakes do not tire the operator so rapidly as do mechanical brakes, and consequently the rate of breakdowns is lowered.

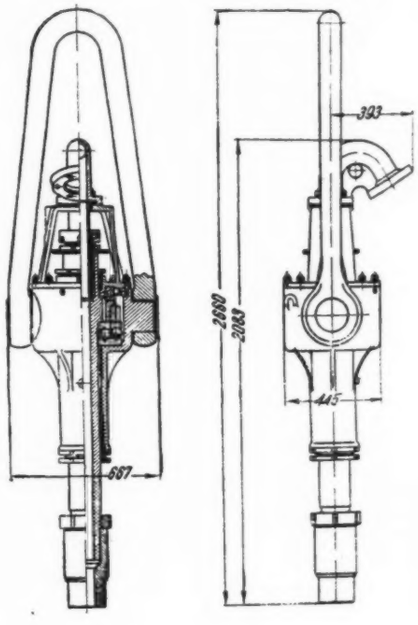


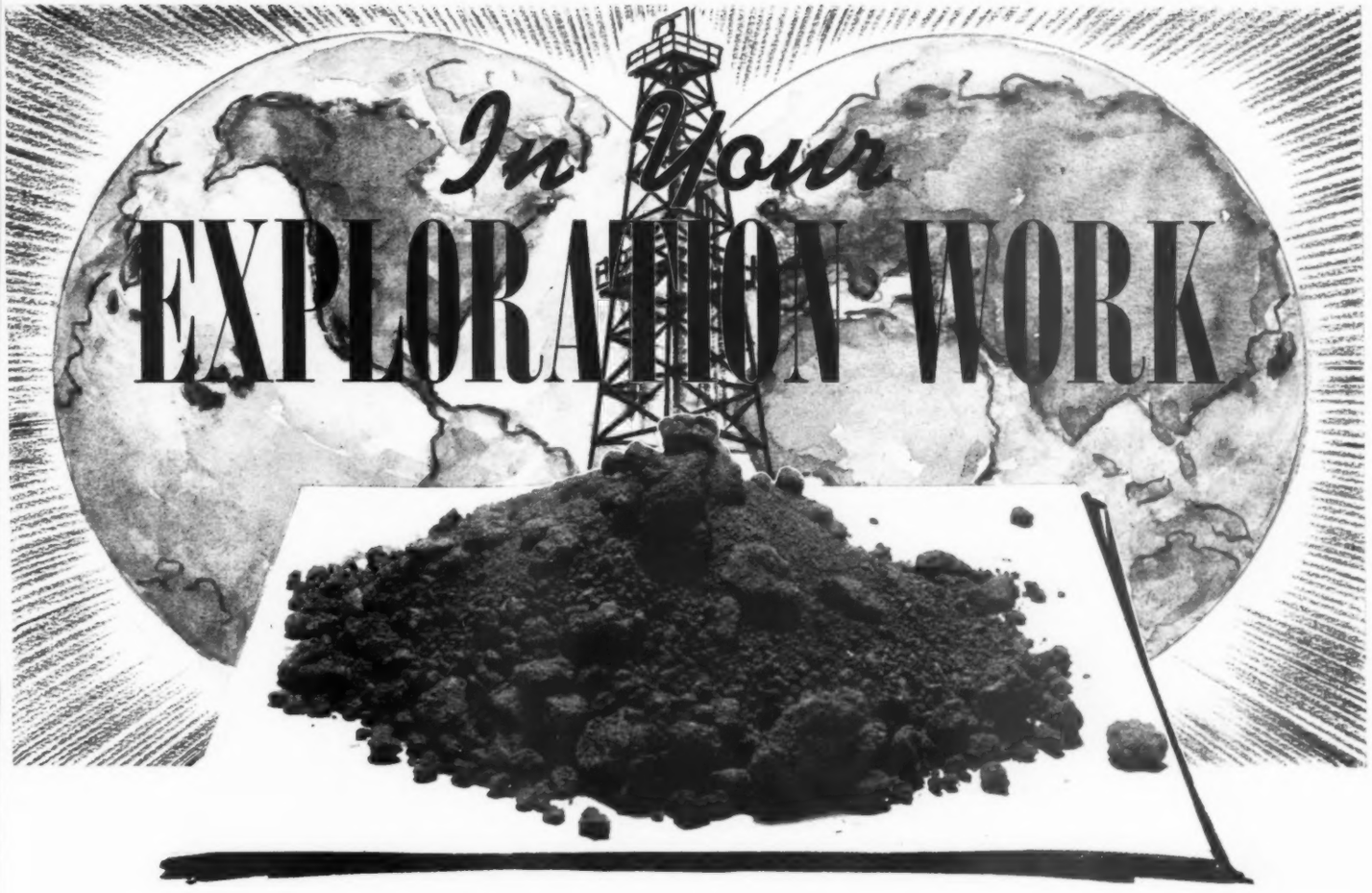
150 ton swivel with conic roller bearings, known in Russia as type SV4-150.

Many improvements are said to have been introduced to the type SV4-150 swivel, capacity 150 tons, which now offers greater steadiness. Base supports are of higher precision and oilers have been improved in design. Both this model and SV5-75, capacity 75 tons, are designed for a speed of 200 r.p.m. In the former radial roller, conic roller and ball bearings are used for directing base and top bearings.

(Continued on page 124)

The SV5-75 swivel for a capacity of 75 tons.





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All types of structures are outlined, anticlinal, faulted traps, stratigraphic, and salt domes . . . an interesting number of Smith Soil Analysis Surveys have been proved by drilling. Ask for literature, cost estimates and other information. No obligation. *Surveys are available in any part of the world.*

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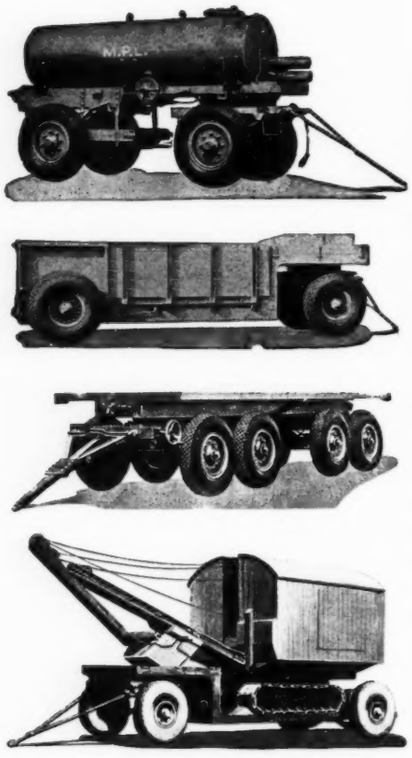

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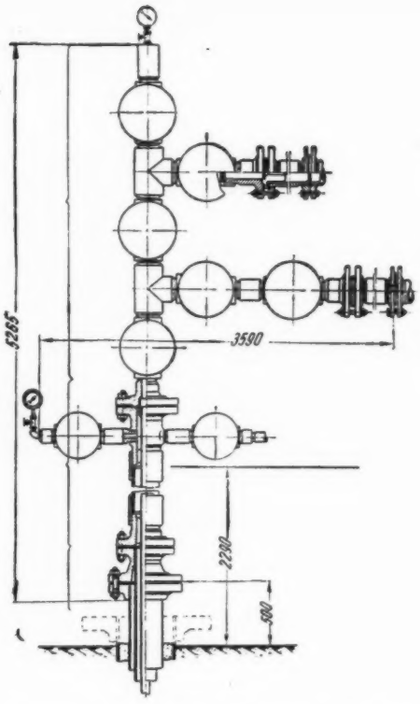


Pressure head hook-up designated in Russia as type AFG-250, capable of handling pressures up to 250 atm.

during the first quarter of the year, compared with 40,443 tons of crude oil and 631,602 tons of refined products during the corresponsing period of 1937. Comparative values of both crude and refined products were Rbl. (gold) 21,140,000 (about $105,-700,000) as against Rbl. (gold) 37,490,000 (about $187,450,000), respectively.

J. WEGRIN.

(Continued from page 118)

while design of the latter provides for four variants of the base bearing—three sizes of ball and one of roller cone type.

In an attempt to speed up operations wedges have been used instead of another set of elevators. The salient feature of these wedges, type KB6, is their light weight and the interchangeable pipe catches of various sizes. These have a fine thread which prevents damage to the pipe. Time spent in running the pipe has been reduced by 40 to 60 percent by their use.

A rather obsolete type of safety reel has been improved to give the new type SKB1. It is regulated by the driller from his position, and the improvement consists of automatic unscrewing of the pipe and drilling tools.

Another case of equipment never tested to the extent of its designed use is type AFG-250 pressure head, which was developed to withstand pressures up to 250 atmospheres and is claimed to represent considerable improvement over previous models. The test unit was installed on a Baku well flowing about 1,100 bbl. of crude oil daily, with considerable gas and sand, from 6,560 ft. through a barrel valve of 8 and 10 mm. and at a pressure of 100 atmospheres. It was tested under reportedly trying conditions and proved satisfactory in operation; but, maximum pressure to which it was subjected was only 140 atmospheres.

EXPORTS

TOTAL Soviet oil exports during the first three months of 1938 were down to 61.3 percent of the 1937 shipments. About 45,000 tons of crude oil and 244,289 tons of refined products were consigned abroad

KIRKUK

(Continued from page 63)

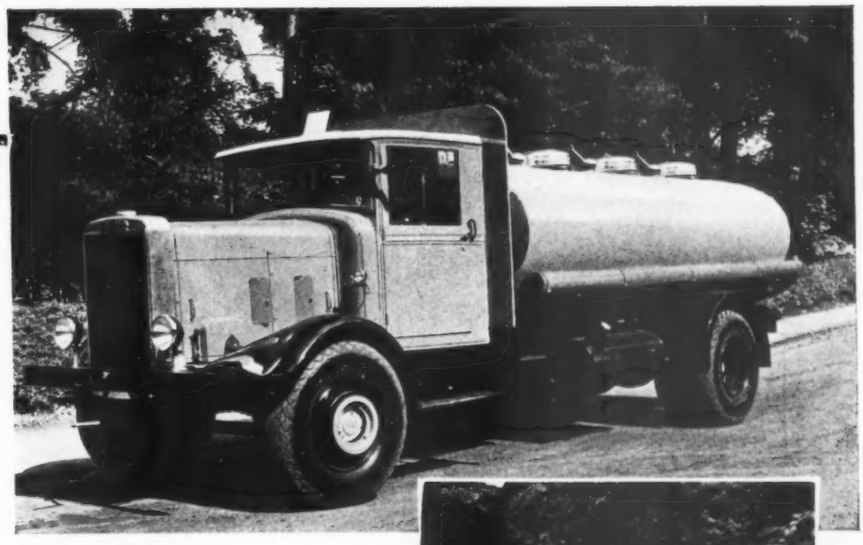
Every effort is made to relieve the monotony of life on the field and at the pump-stations by the provision of facilities for recreation. Tennis courts, golf courses, billiards are available for the sportingly inclined, while gardening affords relaxation for the more sedate. Married men are provided with accommodation for their wives and families.

The houses are of substantial construction and are fitted with all appliances for tempering the heat in the hot weather, and the cold in the winter months (and it can be very cold in the Syrian desert, where frost is not unknown.)

Although temperatures run high in the

(Continued on page 126)

Where Bulk Transport is essential, but difficulties are many, these distinguished Tankers are doing their job . . . with utmost reliability



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Above illustrations show Butterfield Road Tanks on Leyland Chassis

are playing an important part in the development of the mineral resources of the Middle East. Under extreme conditions, across arid deserts and over formidable mountain ranges, these Road Tanks (built and mounted on their chassis at the Butterfield Works at Shipley) are carrying their valuable loads of petrol . . . the motive force of progress to-day. Repeat orders clearly indicate the value placed on Butterfield reliability, by very many prominent operators. We invite you to apply for full data of Road Tanks in Mild Steel, Stainless Steel or Aluminium

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Our engineers always at your service.
Write today for new Bulletin No. 12.

THE AIRETOOL MFG. CO.
SPRINGFIELD, OHIO

(Continued from page 124)

summer months, it is on the whole a healthful climate, and there has been a remarkable freedom from those epidemic diseases such as typhoid, cholera and plague—which make their appearance from time to time in the cities of the Near East. Special care is given to drinking water and an adequate supply of pure ice is always available in the summer months.

The company maintains two hospitals, one at the fields end of the pipeline and one at the pump-station on the Euphrates. The former, which is of recent construction and is air-conditioned, has 26 beds; the latter has 12. For hospital treatment in Palestine, Transjordan, and the Lebanon, the company benefits by the excellent facilities offered in the Government Hospital at Haifa, the Italian Hospital at Amman, the American University Hospital, Beirut, and other institutions in Beirut and Tripoli.

There are also 17 dressing-stations, 12 of which are provided with small two-bedded detention wards. Each pump-station has a dressing-station attached to it.

The company also maintains a traveling dental clinic and eight ambulances.

The medical staff includes six medical officers, 11 assistant medical officers, two dentists and four sanitary inspectors.

The local inhabitants make free use of the facilities available at the company s dressing stations and dental clinic. The number of out-patients treated free of charge at the dressing-stations in 1937 was well over 5,000, while the number of attendances by non-employees at the dental clinic exceeded 1,000. The principal diseases for which resort is had to the company's dressing-stations are diseases of the eye, bronchitis and malaria.

EGYPT

(Continued from page 97)

their oil refining operations that they are contemplating the expansion of the plant by the erection of a new asphalt plant to meet the requirements of the road plan which came into being with the Treaty of Alliance concluded between Great Britain and Egypt in 1936.

Under this treaty the Egyptian Government agreed to construct and maintain in a good state for general traffic 20-feet roads, as follows:

1. Ismailia to Alexandria, via Tel-el-Kebir, Zagasig, Zifta, Tanta, Kafr-el-Zayat and Damanhour.
2. Ismailia to Cairo, via Tel-el-Kebir and thence along the Sweet Water Canal to Heliopolis.
3. Port Said to Suez, via Ismailia.
4. From the south end of the Great Bitter Lake to the Cairo-Suez road at a point 15 miles west of Suez.
5. From Cairo south along the Nile to Kena and Kus.
6. Kus to Kosseir.
7. Kena to Hurghada.

It was understood that Great Britain undertook to improve and maintain the following roads:

1. Cairo to Suez.
2. Cairo to Alexandria via Giza and the desert.
3. Alexandria to Mersa Matruh.

Naturally such roads and their upkeep offer a considerable outlet for asphaltic bitumen, a point of no small importance to Egypt's two refineries as sources of this product.

Progress of refining in Egypt has steadily advanced in recent years, as is shown in the accompanying table which gives details of total refinery output for the years 1934 to 1936.

Output of Egyptian Oil Refineries

	1934 (in tons)	1935	1936
Gasoline	77,025	73,488	83,126
Kerosene	26,329	25,415	28,765
Gas oil	19,319	11,104	16,807
Fuel oil	96,748	121,674	113,815
Diesel oil	12,242	15,471	11,436
Fuel oil	.....	656	753
Total	231,663	247,808	254,702
Asphalt and coke	57,637	91,004	84,408

In order to meet the country's require-

(Continued on page 128)

2. Feeding bar into Medart straightener.

3. Discharging bar from Medart straightener and inspection for accuracy.

4. Heating and forging ends of Sucker Rod Bars.

5. Close-up of three-stage forging operation.

6. Automatic temperature controls for heat treating furnace.

7 Rechecking alignment of forged end with axis of bar.

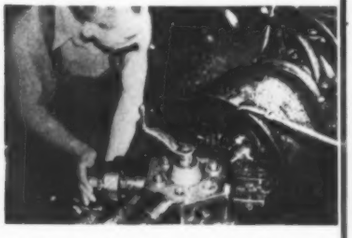
8. Feeding end of heat treating furnace.

9. Discharge end of heat treating furnace 32 feet wide and 36 feet long.

10. Axelson continuous type shot blast cleaning machine.

11. Discharge end of shot blast cleaning machine and inspection for defects.

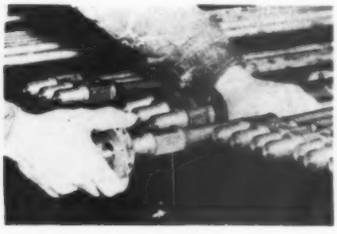
12. Machining and threading Sucker Rod pin ends.



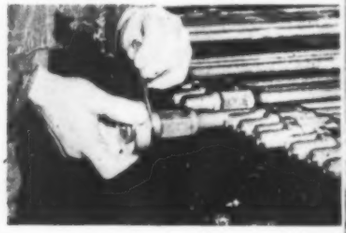
13. Close-up of machining Axelson Sucker Rod pin ends.

14. Gaging threaded pin after machining.

15. Checking form, lead and pitch diameter of thread with "GO" gage.



16. Checking pitch diameter with "NO-GO" gage.



17. Checking relationship of tapered bottom partial threads to base of shoulder.

18. Proper assembly of couplings to prevent reversal of stress in pumping.

19. Careful handling and loading of finished rods in cars.

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For more than forty years Axelson has been looking down oil wells to find the conditions that must be met by Sucker Rods . . . Today, deeper wells, greater friction, heavier strings, longer pumps, corrosive fluids and other adverse factors are all reflected in Axelson's specifications for steel and the special methods for its manufacture into Rods.

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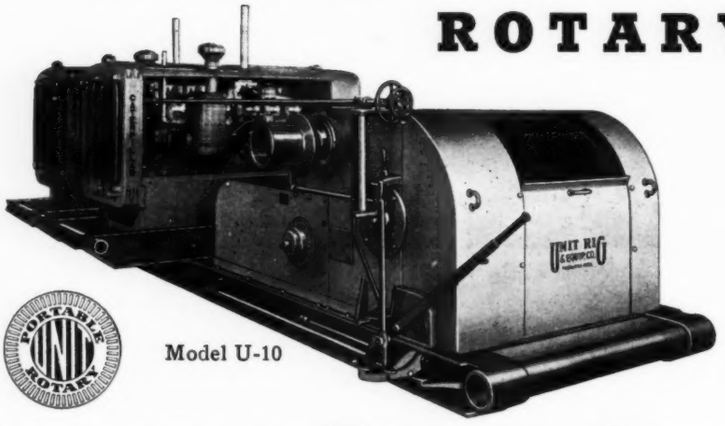

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All chains and sprockets run in oil.
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It will fit most drilling jobs.

Write for details

UNIT RIG AND EQUIPMENT CO.
TULSA, OKLAHOMA

(Continued from page 126)

ments of crude petroleum and products it has been necessary to import both liquid and solid products, the quantities imported during 1934 to 1936 are shown in the accompanying table.

Oil Imports Into Egypt

	1934 In tons	1935	1936
Crude petroleum	110,726	92,416	127,336
Gasoline	12,548	15,124	25,967
White spirit	166	177	106
Kerosene	260,955	253,128	276,832
Fuel oil, etc.	160,338	268,134	241,733
Lubricating oil	17,008	22,451	14,577
Total	561,741	651,430	686,551
Petrolatum	245	298	185
Paraffin wax	467	482	572
Ozokerite and ceresin	15	11	8
Asphalt and bitumen	5,058	6,042	7,321

Consumption of refined petroleum products in Egypt shows a considerable upward trend and, while the average for the ten-year period 1927 to 1936 was 571,100 tons per annum, the total in 1936 was 662,040 tons. The figures in the accompanying table are taken from a recent report by the British Commercial Counsellor at Cairo.

Oil Imports Into Egypt in 1936 by Countries of Origin

	Crude oil	Gasoline	Kerosene	Lubricating oil	Fuel and gas oil	Total
	(In 1,000 barrels)					
Iran	717	66	401	—	909	2,093
Roumania	—	123	1,285	51	311	1,770
U.S.S.R.	—	—	409	—	4	413
Neth. W. Indies	—	—	—	—	354	354
Venezuela	—	—	—	—	107	107
Neth. E. Indies	—	57	—	—	24	81
United States	—	—	—	28	—	28
Belgium and Luxembourg	—	—	—	16	—	16
United Kingdom	—	—	—	9	—	9
Germany	—	—	—	2	—	2
Other countries	189	—	115	2	4	310
Total	906	246	2,210	108	1,713	5,183

Egypt also has a certain amount of export trade, although during the last few years it has been on the decline, as shown in the accompanying table.

Consumption of Petroleum Products in Egypts

	1927-1936 average In tons	1936
Gasoline	60,868	83,560
Kerosene	290,364	304,447
Diesel and gas oils	130,232	187,333
Fuel oil	51,590	30,050
Lubricating oil	18,471	19,935
Bitumen	19,575	36,715
Total	571,100	662,040

Being on the main route from Great Britain and from the Mediterranean to the East, important bunkering centres are located at Port Said and Suez, where are to be seen bulk storage depots of some of the leading companies, including Shell, Vacuum and California Texas Oil Company.

Exports of Petroleum from Egypt

	1934 In tons	1935	1936
Gasoline	27,984	22,923	22,849
Kerosene	551	2,403	1,878
Fuel oil, etc.	1,429	11,150	4,374
Fuel oil (bunkers)	61,581	49,504	47,901
Lubricating oil	62	70	182
Asphalt	46,537	75,231	47,966
	138,144	161,281	125,150

INDIA

(Continued from page 93)

the rate of 23 bbl. per hour for 24 hours. The caving formation mentioned, shut this oil off and the well had to be cleaned out and the casing run to shut off the cavings.

This was accomplished by landing a string of casing at 7,844 ft. and the oil flowed inside and outside this casing, at the rate of about 200 bbl. per day in all, from the upper and lower strikes. The oil at the bottom did not flow freely from the bottom, and the oil there—apparently of good quality and similar to the Khaur oil—was apparently largely shut off.

Some water then showed up and the source was investigated by various tests before it was decided to produce only the black oil from higher up and concentrate on a new well, which was fully justified by the good indications of green oil in the first deep test.

On May 15th, 1937, Attock brought in this additional test flowing 590 to 600 bbl. per day through a ½-in. bean. The oil was of good quality and came from the 7,715 ft. level. Production of this test, called the Coronation Well now remains steady at about 454 bbl. daily with no signs of water. It seems reasonable to assume that this well which is higher up on the structure, will remain water free and that the first deep well had encountered edge conditions.

(Continued on page 130)

ALCO in IRAN

25,000 bbl/day—Single Debutanization Unit

One of the largest single unit pressure distillate fractionation plants in the world is the Alco-designed-and-fabricated unit in Iran.

Unstable pressure distillate is processed in a 9 ft. x 70 ft. debutanizing tower for close fractionation. Reboil heat of 25,500,000 BTU/hr. is supplied by circulation of tower bottoms thru a furnace operating at an efficiency of 74%.

95% of the butane and lighter fractions are removed, and 99.6% of the pentane and heavier fractions are retained.

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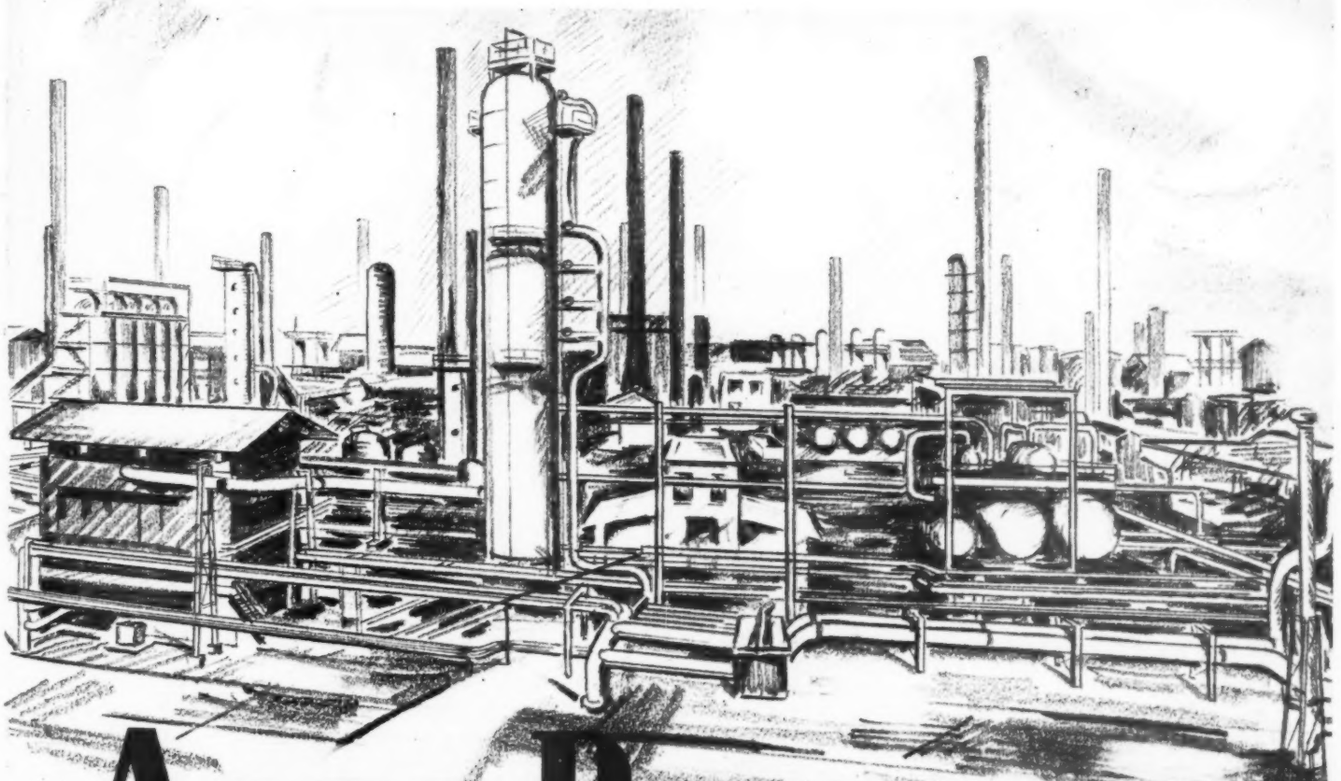

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c/o Elks Club, 17th and I Streets, Bakersfield, Calif.
1409 East Valley Road, Santa Barbara, Calif.

(Continued from page 128)

The third deep well at Dhulian was drilled into the green oil at 7,659 ft. early in November, 1937. Initial flow rose to 800 bbl. per day but is now 480 bbl.—a considerable extent due to reduction in size of bean from $\frac{5}{16}$-in. to less than $\frac{1}{4}$-in. This restriction was considered advisable partly from the storage standpoint and partly in the interests of economical recovery of production.

Developments at other drilling wells are as follows: one well encountered a good show of black oil at 6,200 ft.—about 50 bbl. daily—but is being carried down to the deep horizon of the two main producers. Another well which did not give black oil in any appreciable quantity has been drilled to 7,553 ft. and is now being cemented. A further well has reached the depth of 3,020 ft. and new sites have been selected for additional wells. Should results at Dhulian continue to be as favorable as the earlier tests, consideration will be given to extensive alterations and additions to Attock's Rawalpindi refinery.

A well not previously mentioned had been drilled to 3,470 ft., where it got into trouble in a water sand and further deepening became impossible. It is now contributing to its cost by supplying water for field operations.

OUTFIELDS

Kharpa was first drilled in 1915, but is comparatively unimportant. Between 1930 and 1934 Attock tested the Khaire Murat area several times—only small quantities of oil were obtained. Discouraged by lack of success with wells drilled at Chharat, that area was given up during the latter year. In 1935 a test well was drilled at Bokra to 3,505 ft. in which several oil shows were obtained, but no commercial flow. This test has necessitated a revision of the forecast of underground structural conditions before further tests.

No further work has been undertaken at the outfields, due to concentration of resources and energy on Khaur and Dhulian. Several areas are held under licence by Attock Oil Company Ltd., including prospecting licences over 150 acres in Dera Ismail Khan district. Indo-Burma Petroleum Company Ltd., on whom Attock has a call through its managing agents, has recommended the testing of an appreciable area with good prospects near Rawalpindi, eight miles by road from the refinery. Two other areas have also been recommended, neither of which calls for an extensive test.

The geological staff of Indo-Burma Petroleum Company Ltd. has been concentrating in Punjab and North-West

(Continued on page 132)

OIL FIELD MAPS

OIL FIELDS OF WORLD In 2 colors; 2 sheets; size 80x44; Mercator projection. At the bottom, and forming a part of the map, are 7 large-scale inset maps of California, Mid-Continent, Mexico, Venezuela, Trinidad, Colombia, Iran, Iraq and Russia; also table of crude production by countries for 8 years, viz, 1930 to 1937. Official names of fields in red. *Price, $5.00 paper**

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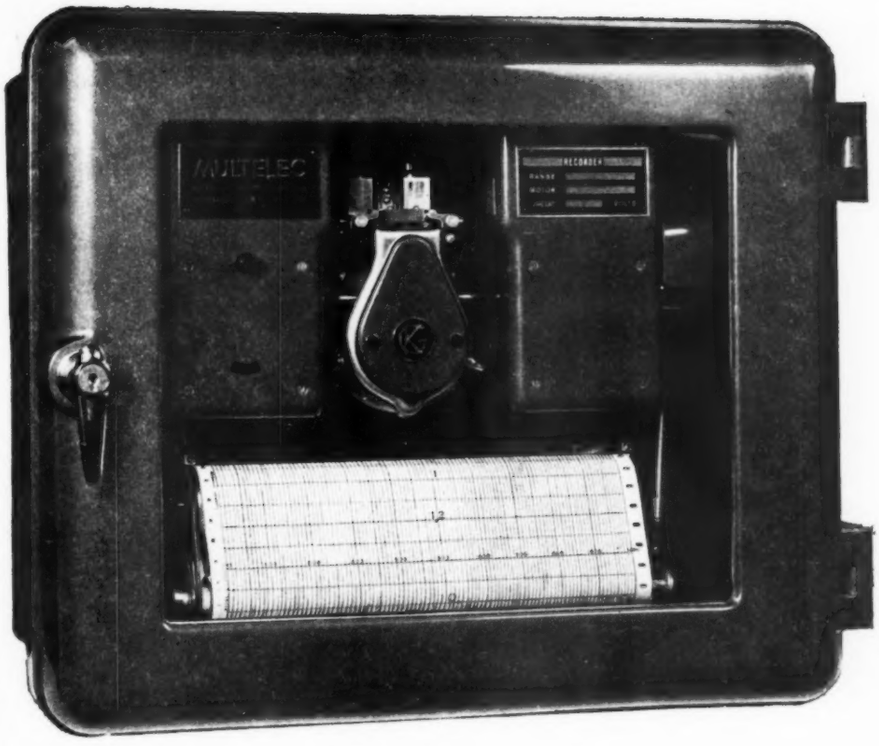

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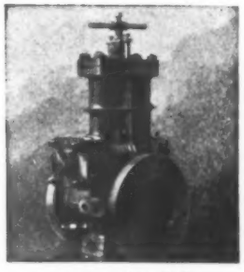
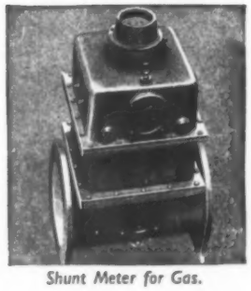


Interchangeable Orifice



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(Continued from page 130)

Frontier Province with a view to clearing up all outstanding problems and examining all possibilities. According to last reports, Indo-Burma held 18,833.8 acres of North-West Frontier Province under prospecting licence, of which 9,718.6 acres were in Bannu district, 2,995.2 acres in Dera Ismail Khan, and 6,120 acres in Kohut.

Activity in western India is being intensified. Burmah Oil Company is understood to hold prospecting licences over a total of 2,535.2 acres in the Attock district in addition to its interest in Attock Oil Company. More recently (January, 1938) a report has come from Calcutta that oil had been found in the Suleiman mountain range, near Fort Munro. Immediately upon receiving the report Burmah Oil sent an expert by airplane to examine the oil on the spot. Fort Munro is about 150 mi. south-southwest of Dera Ismail Khan and apparently quite near, if not actually in, the Mari Hills where oil was obtained about a half a century ago.

Another district previously prospected which is due for further prospecting is Sind. Two companies applied to the government of Sind during November, 1937, for licence to prospect for oil and gas. It is believed that the government will refrain from granting licences until further preliminary investigations have been made.

Only information disclosed as to the identity of the two concerns was that application had been made by "a company operating in Assam, and another large concern." The only company known to fit the former discription would be Assam Oil Company Ltd., subsidiary of Burmah Oil.

The Sind desert lies in the oil belt and certain schools of geologists have always maintained that oil will some day be found there.

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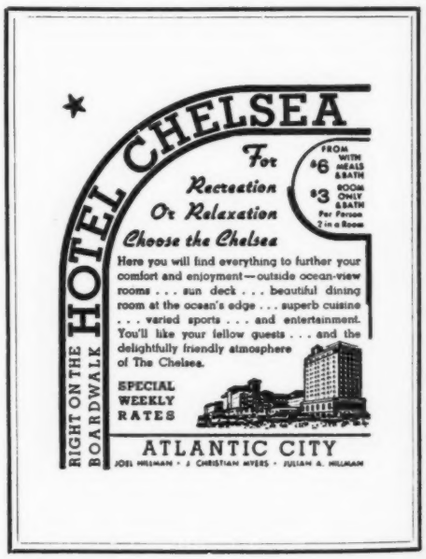
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